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BACKLIGHT INCLUDING EXTERNAL ELECTRODE FLUORESCENT LAMP AND METHOD FOR DRIVING THE SAME

Abstract:

Abstract of WO0179922

The present invention discloses a backlight including external electrode fluorescent lamps and a method for driving the backlight. The backlight includes fluorescent lamps having external electrodes made of an electrically conductive material for wrapping outer peripheral surfaces including edge cross-sections on both ends of a glass tube with a layer of fluorescent substance applied thereon. The backlight is constructed in a manner that a plurality of such fluorescent lamps are installed at outer portions of a plastic light guide; that an alternating current type power source is applied from the outside to the fluorescent lamps by installing a plurality of the fluorescent lamps between a reflecting plate and a diffusing plate and electrically connecting them with one another; or that the fluorescent lamps are installed at a predetermined interval between upper and lower substrates with a layer of fluorescent substance applied thereon and spaced from each other, and electrodes to which an alternating current type power source is applied from outside are formed on opposite outer or inner faces of the assembled upper and lower substrates. According to the present invention, since the electrodes of the fluorescent lamps are formed at external portions and are repeatedly disposed, the fluorescent lamps can be interconnected in parallel to and driven by a single power source. Further, since the fluorescent lamps serve as a partition and simultaneously emit light by themselves, their uniform luminance can be maintained and thinner backlight can be obtained. The backlight of the present invention is driven by a square wave from a switching inverter, and is characterized by the use of an overshooting waveform and a self-discharge effect favorable to an initial discharge, thereby driving it by a low frequency of several dozen kHz and thus realizing high luminance and high efficiency.

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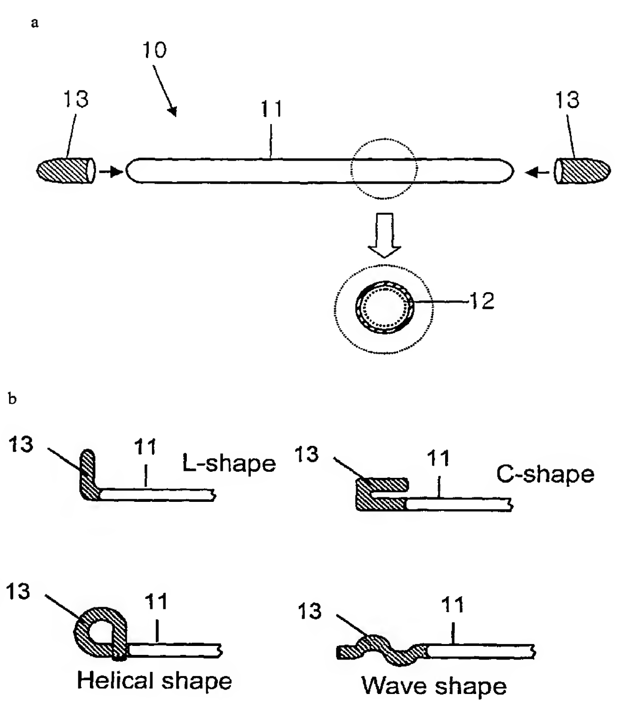

(57) Abstract: The present invention discloses a backlight including external electrode fluorescent lamps and a method for driving the backlight. The backlight includes fluorescent lamps having external electrodes made of an electrically conductive material for wrapping outer peripheral surfaces including edge cross-sections on both ends of a glass tube with a layer of fluorescent substance applied thereon. The backlight is constructed in a manner that a plurality of such fluorescent lamps are installed at outer portions of a plastic light guide; that an alternating current type power source is applied from the outside to the fluorescent lamps by installing a plurality of the fluorescent lamps between a reflecting plate and a diffusing plate and electrically connecting them with one another; or that the fluorescent lamps are installed at a predetermined interval between upper and lower substrates with a layer of fluorescent substance applied thereon and spaced from each other, and electrodes to which an alternating current type power source is applied from outside are formed on opposite outer or inner faces of the assembled upper and lower substrates. According to the present invention, since the electrodes of the fluorescent lamps are formed at external portions and are repeatedly disposed, the fluorescent lamps can be interconnected in parallel to and driven by a single power source. Further, since the fluorescent lamps serve as a partition and simultaneously emit light by themselves, their uniform luminance can be maintained and thinner backlight can be obtained. The backlight of the present invention is driven by a square wave from a switching inverter, and is characterized by the use of an overshooting waveform and a self-discharge effect favorable to an initial discharge, thereby driving it by a low frequency of several dozen kHz and thus realizing high luminance and high efficiency.

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Backlight Including External Electrode Fluorescent Lamp and Method for Driving the Same

Field of Invention

The present invention relates to a fluorescent lamp having external electrodes and a backlight, and more particularly, to an improved backlight including an external electrode fluorescent lamp in which the external electrodes are installed at both ends of an electrodeless fluorescent lamp and a plurality of electrodes are electrically connected to one another, and a method for driving the backlight.

Background of Invention

In general, a flat panel display is categorized as an active lighting type or a passive lighting type. The active lighting type includes a flat panel cathode-ray tube, a plasma display panel, an electronic active lighting element, a fluorescent display, a active lighting diode, etc. The passive lighting type includes a liquid crystal display.

In the liquid crystal display of a passive lighting type flat panel display, the image is formed not by self-illumination but by the incidence of light from the outside of the liquid crystal panel.

In order to solve the above problem, the backlight is installed at a rear face of the liquid crystal panel to enable irradiation of the display. Thus, the image formed on the liquid crystal display can be seen even in dark places. General requirements of the backlight are high luminance, high efficiency, uniformity of the luminance, long life, thinness, light weight, low costs, etc. High efficiency and long life of the lamp is required for use in notebook PCs so as to reduce the electrical power consumption, whereas high luminance is needed in a backlight for use in monitors and TVs.

A type in which a cold cathode fluorescent lamp (CCFL) is arranged, and a flat fluorescent lamp type in which lower and upper substrates with a fluorescent substance applied thereto are assembled, are both widely used for backlights. The CCFLs can be divided into (i) edge light types using a plastic light guide and (ii) direct light types in which repeated light sources are disposed on a plane, in accordance with arrangement of the light source with respect to a display face.

However, the CCFL according to the prior art operates at a high luminance of about 30,000 cd/m^2, and as a result has a problem of lamp life. In particular, the edge light type is not suitable for a large screen panel in that luminance of the panel is low even though the CCFL itself is highly luminescent. In the direct light type, it is impossible to connect the CCFLs in parallel and to drive by a conventional inverter, and the arrangement distance between the CCFLs is large because the number of the

CCFLs disposed on a plane is limited in order to attain optimal luminance of the panel. Thus, a reflecting plate having a specific structure is required. Simultaneously, the thickness of the panel is with the distance between a diffusing plate and lamps in order to obtain uniform luminance.

In the flat fluorescent lamp type it is necessary to have a sufficient thickness to prevent a substrate made of glass from being damaged, since pressure between the upper and lower substrates to be assembled is lower than atmospheric pressure. As a result, there is a shortcoming in that the lamp weight increases. Further, in case of the flat fluorescent lamp type, partitions and spacers made in the form of a bead or a cross are interposed between the upper and lower substrates in order to enlarge a screen area. Thus, the problems of weight increase due to the increase of the substrate thickness and of heat generation due to low efficiency are more serious. In case of using the partitions, uniform luminance cannot be ensured since striped patterns of the partitions appear on the screen.

Accordingly, it is required that the backlight be developed, so that it can be made lighter while ensuring high luminance and efficiency of the size-increasing liquid crystal display.

The present invention is contemplated to solve the problems mentioned above. Further, the present invention is intended to provide a backlight including an external electrode fluorescent lamp, in which external electrodes are formed at electrodeless glass tubes, are overlapped, and can be driven in parallel. Furthermore, the invention intends to provide a method for driving the backlight.

The electrode structure of the conventional external electrode fluorescent lamp (EEFL) includes various types, such as a belt type; a type that metal caps are bonded to a glass tube; a type in which spaces at both ends of the glass tube are bulged, etc. (Figure 11). Although the EEFL was intended to have longer life than the CCFL, it was not generally used as a light source for the backlight due to the problems of a EMI, low efficiency, and a large size power source since high luminance can be obtained by driving the EEFL with a high frequency of about several MHz. Further, the EEFL was not employed as a light source of the backlight since its luminance and efficiency are low when a LC-resonance type inverter for driving the CCFL is used for driving the EEFL.

Figure 11 shows the shapes of the conventional external electrode fluorescent lamps as compared to those of the present invention. Figure 11 (a) is a belt type external electrode characterized in that plurality pairs of the belt type electrodes are installed on a cylinder of the glass tube, and in that it can be driven at a high frequency of several MHz by decreasing the length of respective belt type electrodes.

The belt type EEFL in Figure 11 (a) has an advantage that the electrodes can be further installed even at an intermediate portion of the glass tube since they are mounted on the cylinder of the glass tube. Recently, the backlight was constructed in a manner that the belt type external electrode fluorescent lamps are directly disposed onto the reflecting plate. And then, the external electrode fluorescent lamps attain high luminance of several 10,000 cd/m^2 by driving the lamps at a high frequency of several MHz. In case of the elongate glass tube, installation of the belt type electrodes onto the intermediate portion of the glass tube is helpful to such a high frequency driving. However, there are problems in that uniformity and thinning of the panels cannot be realized due to decrease of luminance of the electrode portion. Furthermore, the high frequency driving basically results in problems in that EMI is emitted, efficiency of the electrodes is low, the high frequency power source cannot be made in a compact size, etc. The foregoing problems are disclosed in Japanese Patent Publication No. (Sho) 60-25488 (February 13, 1985), Korean Patent Application No. 10-1999-0052964, and Japanese Patent Application No. 98-336926 (November 27, 1998).

Figure 11 (b) is an external electrode of a type in which metal capsules are bonded at the ends of the glass tube, and is characterized in that ferrodielectrics are applied onto the inside of the metal capsules. This type is disclosed in United States Patent No. 2,624,858 (June 6, 1953). The type of Figure 11 (b) is employed in case where the diameter of the glass tube is large. That is, in cases where the glass tube is thick, this type can be employed because of the electric capacitive voltage drop due to the glass tube itself. However, the bonded portions of the electrodes can be easily damaged since the coefficient of thermal expansion of the glass tubes is different from that of the metal. However, in case of a fine glass tube, like a cold cathode-ray tube generally used in the existing backlight, having its outer diameter of 2.6 mm and its thickness of 0.5 mm or less, the type in which the metal capsules are bonded to the glass tubes does not have to be used since the electric capacitive voltage drop due to the thickness of the glass tube is small.

Figures 11 (c) and (d) show lamps which are formed in a manner that the spaces at both ends of the glass tube are larger than that of an intermediate portion for the purpose of high luminance and efficiency. It is disclosed in United States Patent Nos. 1,612,387 (November 28, 1926) and 1,676,790 (July 10, 1928). When the spaces at both ends of the glass tube are expanded as mentioned above, the luminance and efficiency of the lamp increase but it is difficult to apply this structure to a fine tube.

The external electrode of the present invention can be applied to a fine tube

having an outer diameter of several mm, and it includes various types which can be modified on the basis of end-cap type electrode which both ends of the sealed glass tube are covered with. The end-cap type electrode for wrapping around a cylindrical surface in addition to edge faces at both ends of the glass tube is advantageous over the belt type electrode for covering only the cylindrical surface, thereby achieving higher luminance and efficiency. According to the test results of the present applicant, higher luminance can be obtained as the electrode length in a direction of the glass tube increases. However, effective active lighting face decreases as the length of the electrode increases. Thus, when the electrode is employed in the backlight, the edge area of the panel from which light is not emitted increases because the electrode portions are large. Accordingly, the end-cap type is advantageous over the belt type from the viewpoint that the electrode can be shortened. And particularly in the present invention, the belt type electrode does not have to be formed at the intermediate portion of the glass tube in its longitudinal direction. Currently, it is difficult to employ the type for expanding spaces at both ends of the glass tube due to the manufacturing process of the fine tube. In the present invention, a length of the electrode at both ends of the glass tube is first predetermined. When the end-cap electrode is used as a light source for either the edge light type or direct light type backlight, the length of the electrode is sufficiently maintained by bending the ends of the glass tube (unlike the straight metal capsule type) in order to minimize the edge area from which the light is not emitted. Thus, high luminance and efficiency of the electrode can be obtained

In another aspect of the present invention, a method for driving the backlight employing the external electrode fluorescent lamps is provided, and in particular, a driving circuit for achieving uniform and high luminance and high efficiency of the large backlight is provided.

The prior technique for driving the cold cathode fluorescent lamp used generally in the conventional backlight is disclosed in Korean Patent Laid-Open Publication No. 1998-028921.

Figure 12 is a circuit diagram showing an IC for driving the CCFL for use in the LCD panel disclosed in the prior art. It also shows a peripheral circuitry, and includes a lamp driving IC 100 having a plurality of I/O pins, a main electrical power circuit portion 120 having a half bridge circuit, and a lamp 140.

The lamp driving IC 100 comprises a first pin 1 connected to an input voltage terminal, a second pin 2 connected to a predetermined minimum frequency terminal, a third pin 3 connected to a predetermined maximum frequency terminal, a fourth pin 4 connected to a ground voltage terminal, a fifth pin 5 connected to a feedback ground

terminal, a sixth pin 6 connected to a predetermined comparative terminal, a seventh pin 7 connected to a predetermined internal high voltage terminal, and a eighth pin 8 connected to a predetermined external control signal terminal for determining ON/OFF of the IC circuit.

Further, the main electrical power circuit portion 120 comprises the half bridge circuit which responds to an output signal of the predetermined pin of the lamp driving IC 100 and has a plurality of passive elements. The lamp 140 is constructed to be driven in response to a predetermined output signal of the main electrical power circuit portion 120.

As a prior art example, power is supplied to the CCFL employed in the LCD backlight by means of an inverter. A principle of the inverter is to obtain a high voltage required for initiation and maintenance of the CCFL discharge from a low alternating voltage of several ten kHz, obtained from the LC-resonance type inverter by means of a boosting transformer. Here, a waveform outputted from the inverter takes the shape of sine wave. The LC-resonance type inverter has advantages that the device is simple and highly efficient. On the other hand, it is impossible to connect the CCFLs in parallel and to drive the CCFLs by a single inverter. Therefore, the backlight in the form of direct light type or the type in which a plastic light guide is combined with the CCFLs, requires the number of the inverter to correspond to the number of the CCFLs.

The direct light type backlight, in which a plurality of the external electrode fluorescent lamps are disposed at edge areas or on a plane of the plastic light guide, can be driven by a single inverter by connecting the EEFLs in parallel. The reason is as follows: Since the electrode for the EEFL is not exposed at the discharge space, real current does not flow to the electrode, wall charges are collected on both electrode portions, and the discharge at both ends of the lamp is interrupted by formation of a reverse voltage due to the wall charges. Then, another lamp is discharged, and likewise the other wall charges are formed and the other lamps are sequentially discharged. Therefore, a plurality of the lamps can be light emitted by a single inverter. However, since the method for driving the EEFL by using the inverter from which sine waves used for driving the CCFLs are outputted cannot efficiently control the wall charges, it produces much lower luminance and efficiency than that of the EEFL having a single tube. In addition, when a plurality of EEFLs interconnected in parallel are driven by this inverter, the number of active lighting EEFLs is limited since a time period wherein a high voltage is applied during one cycle is limited. Therefore, uniform luminance cannot be realized in case of the backlight where a number of the EEFLs are disposed on the plane thereof.

As mentioned above, even if the EEFLs can be driven by the LC-resonance type inverter of several ten kHz used in driving the CCFL, the backlight using the EEFL cannot be efficiently realized. Further, adoting the conventional high frequency driving of the EEFLs at several MHz, the problems of EMI, low efficiency and miniaturization of power source, etc. cannot be easily overcome.

Summary of Invention

The present invention is contemplated to solve the problems mentioned above. It is an object of the present invention to provide a backlight including external electrode-type fluorescent lamps capable of being driven in a parallel connection by disposing external electrodes formed at electrodeless glass tubes on outer portions of a plastic light guide or by superposing the electrodes on a reflecting plate, and to provide a driving method for achieving uniform and high luminance and high efficiency of the backlight.

The present invention provides external electrode fluorescent lamps capable of obtaining high luminance and efficiency by a low frequency driving of 100 kHz or lower and a backlight including the fluorescent lamps.

The fluorescent lamps are generally driven by a LC-resonance type inverter. However, by driving the external electrode fluorescent lamps according to the present invention by a switching inverter circuit which outputs square wave pulses, the present invention has obtained at least two times luminance and efficiency as compared to the driving method using the LC-resonance type inverter. That is, with respect to a single tube of the external electrode fluorescent lamps having an outer diameter of 2.6 mm and generally employed in the LCD-backlight, high luminance of several 10,000 cd/m^2 and high efficiency of 50 lm/W or more were achieved. In particular, according to the test results of the present applicant, the EEFL has achieved greater efficiency than the CCFL at the point of luminance of about 10,000 cd/m^2. Therefore, the EEFL would do credit to a light source of the backlight, if it can operate at the point of luminance having better efficiency based on the above characteristics. Unlike the CCFL, the present invention has further advantages in that the lamps have longer life, electrodeless lamps can be easily manufactured, and in that the lamps can be driven by a single inverter when a plurality of the external electrode fluorescent lamps are interconnected in parallel.

Similar to the CCFL, the external electrode fluorescent lamps can be used in the form of an edge light type and a direct light type in the present invention. It is another object of the present invention to provide luminant partition type fluorescent lamps and a backlight employing the lamps, wherein the plurality of fluorescent lamps

with external electrodes formed are disposed between upper and lower substrates with fluorescent layers formed thereon and used also as partitions. The present invention is contemplated to solve the problems of driving the backlight employing the fluorescent lamps mentioned above, and of driving the large backlight made by arranging the lamps in a plane. It is still another object of the present invention to provide a driving method for achieving uniform and high luminance and high efficiency of the large backlight.

In order to achieve the above objects, an external electrode fluorescent lamp according to one aspect of the present invention comprises a glass tube into which a discharge gas is injected, of which an inner peripheral wall is coated with a layer of fluorescent substance, and of which both ends are then hermetically sealed; and end-cap type external electrodes configured to take the shape of bends such as an L-shape, a C-shape, a helical shape or a wave shape and to wrap both ends of the glass tube.

In addition, a backlight according to another aspect of the present invention comprises a plastic light guide; fluorescent lamps disposed at edges of the plastic light guide and including glass tubes into which a discharge gas is injected, of which inner peripheral walls are coated with a layer of fluorescent substance, and of which both ends are then hermetically sealed, and end-cap type external electrodes for wrapping both ends of the glass tubes; and a switching inverter connected to the external electrodes for applying square wave signals having a frequency of 100kHz or lower to the external electrodes. The external electrode fluorescent lamps include a plurality of external electrode fluorescent lamps interconnected in parallel.

Furthermore, a backlight according to a further aspect of the present invention comprises a plurality of external electrode fluorescent lamps interconnected in parallel and including glass tubes into which a discharge gas is injected, of which inner peripheral walls are coated with a layer of fluorescent substance, and of which both ends are then hermetically sealed, and end-cap type external electrodes for wrapping both ends of the glass tubes; electrode connecting lines for connecting the end-cap type external electrodes of the plurality of external electrode fluorescent lamps in parallel; a reflecting plate; a diffusing plate; and a switching inverter connected to the electrode connecting lines for applying square wave signals having a frequency of 100kHz or lower to the electrode connecting lines. The reflecting plate further includes a plurality of triangular stands interposed between the external electrode fluorescent lamps. The reflecting plate is in the form of wave for wrapping the external electrode fluorescent lamps. The backlight further includes a plastic light guide having diffusing grooves in which the external electrode fluorescent lamps are seated. The reflecting plate is in the form of triangular sawteeth and the external

electrode fluorescent lamps are disposed along troughs of the triangular sawteeth.

Moreover, a backlight according to a further aspect of the present invention comprises glass tubes into which a discharge gas is injected, of which inner peripheral walls are coated with a layer of fluorescent substance, and of which both ends are then hermetically sealed; socket-type multiple capsule electrode structures having a plurality of parallel-connected external electrode with which the glass tubes are coupled; a reflecting plate; a diffusing plate; and a switching inverter connected to the socket-type multiple capsule electrode structures for applying square wave signals having a frequency of 100kHz or lower to the socket-type multiple capsule electrode.

In addition, a backlight according to a further aspect of the present invention comprises external electrode fluorescent lamps with external electrode portions thereof alternately disposed and transversely overlapped with each other in the middle of a panel; a reflecting plate; a diffusing plate; and a switching inverter connected to the external electrodes for applying square wave signals having a frequency of 100kHz or lower to the external electrodes. Each of the fluorescent lamps includes a glass tube into which a discharge gas is injected, of which an inner peripheral wall is coated with a layer of fluorescent substance, and of which both ends are then hermetically sealed; and cap type external electrodes for wrapping both ends of the glass tube. The external electrodes of the external electrode fluorescent lamps are made of conductive transparent electrode materials.

Furthermore, a backlight according to a further aspect of the present invention comprises an upper substrate with an upper layer of fluorescent substance applied on a bottom surface of the upper substrate; a lower substrate with a lower layer of fluorescent substance applied on a top surface of the lower substrate and which is installed to be opposite to the upper substrate; edge supporting stands interposed between the upper and lower substrates for hermetically sealing the upper and lower substrates; external electrode fluorescent lamps installed at a predetermined interval above the lower substrate; electrodes formed at corresponding outer surfaces on both sides of the assembled upper and lower substrates, respectively, and connected to electrode connecting lines to which an alternating current type power source is applied; a switching inverter connected to the electrodes for applying square wave signals having a frequency of 100 kHz or lower to the electrodes; and a discharge gas injected into an inner space upon sealing the upper and lower substrates. Each of the fluorescent lamps includes a glass tube into which a discharge gas is injected, of which an inner peripheral wall is coated with a layer of fluorescent substance, and of which both ends are then hermetically sealed; and capsule type external electrodes for wrapping both ends of the glass tube. The external electrode fluorescent lamps are

not connected to the electrodes but disposed within the upper and lower substrates in a floating state.

Moreover, a backlight according to a further aspect of the present invention comprises an upper substrate with an upper layer of fluorescent substance applied on a bottom surface of the upper substrate; a lower substrate with a lower layer of fluorescent substance applied on a top surface of the lower substrate and which is installed to be opposite to the upper substrate; edge supporting stands interposed between the upper and lower substrates for hermetically sealing the upper and lower substrates; multiple capsule type electrode structures constructed by coupling upper and lower electrodes having surfaces coated with ferrodielectrics and grooves at a predetermined interval and then installed respectively on inner portions at both ends of the lower substrate; glass tubes coupled with, in parallel, the grooves of the multiple capsule type electrode structures installed respectively on inner portions at both ends of the lower substrate; electrode connecting lines connected to the multiple capsule type electrode structures; a switching inverter connected to the electrode connecting lines for applying square wave signals having a frequency of 100 kHz or lower to the electrode connecting lines; and a discharge gas injected into an inner space upon sealing the upper and lower substrates. Each of the glass tubes has a discharge gas injected therein and an inner peripheral wall coated with a layer of fluorescent substance. Both ends of each of the glass tube are then hermetically sealed.

Furthermore, the switching inverter constitutes a bridge circuit by four FETs A, B, C and D. A DC is applied to drains of the FETs A and C; sources of the FETs B and C are grounded; sources of FETs A and C are connected to drains of the FETs B and D, respectively; and a boosting transformer is connected between a connection point of the FETs A and B and a connection point of the FETs C and D. A square wave outputted from the switching inverter includes an overshooting.

Moreover, a drive method for driving a backlight with a plurality of external electrode fluorescent lamps interconnected in parallel comprises the steps of dividing the plurality of external electrode fluorescent lamps into a plurality of predetermined regions; connecting identical electrode connecting lines to external electrodes of the fluorescent lamps in the respective divided regions, respectively; connecting switching inverters for outputting square waves to the electrode connecting lines connected to the respective divided regions, respectively; applying an identical gate signal to each of the switching inverters; and supplying the electrode connecting lines with the in-phase square waves from the switching inverters in response to the gate signal. The switching inverter constitutes a bridge circuit by four FETs A, B, C and D. A DC is applied to drains of the FETs A and C, sources of the FETs B and C are grounded,

sources of the FETs A and C are connected to drains of the FETs B and D, respectively, and a boosting transformer is connected between a connection point of the FETs A and B and a connection point of the FETs C and D.

Brief Description of the Drawings

Figure 1a is a perspective view of a straight end-cap type external electrode fluorescent lamp according to an example of the present invention.

Figure 1b is a partial perspective view of curved external electrode fluorescent lamps according to another example of the present invention

Figure 2 shows illustrative views of arrangement manners of the backlight according to a first embodiment of the present invention, wherein external electrode fluorescent lamps are disposed at edge areas of a plastic light guide.

Figure 3a is an illustrative view showing an arrangement manner of the straight end-cap type fluorescent lamps of the direct light type backlight according to a second embodiment of the present invention.

Figure 3b is an illustrative view showing an arrangement manner of the curved electrode type fluorescent lamps of the direct light type backlight according to the second embodiment of the present invention.

Figure 3c is an illustrative view showing another arrangement manner of the curved electrode type fluorescent lamps of the direct light type backlight according to the second embodiment of the present invention.

Figure 3d is an illustrative view showing an arrangement manner of elongate fluorescent lamps bent at edge areas in the direct light type backlight according to the second embodiment of the present invention.

Figure 3e is an illustrative view showing a connection manner by overlapped capsule structures of the direct light type backlight according to the second embodiment of the present invention.

Figure 3f is an illustrative view showing a lamp-directional overlapped manner of the direct light type backlight for use in a large screen according to the second embodiment of the present invention.

Figure 4 is an exploded perspective view of a direct light type backlight according to the second embodiment of the present invention.

Figure 5 shows illustrative views showing arrangement manners of a reflecting plate and fluorescent lamps of the direct light type backlight according to the second embodiment of the present invention.

Figure 6a is an exploded perspective view showing a state before a luminant partition type backlight according to a third embodiment of the present invention is

assembled.

Figure 6b is a partially cut-away and exploded perspective view showing a state after the backlight of Figure 6a is assembled.

Figure 6c is a conceptual view for illustrating a connection manner of electrodeless fluorescent lamps and multiple capsule electrodes that are disposed within substrates of the luminant partition type backlight according to the third embodiment of the present invention.

Figure 7 is a schematic diagram showing a switching inverter according to an embodiment of the present invention and signal waveforms applied to gates of the inverter.

Figure 8 is a schematic diagram showing a change of an output signal waveform of a switching inverter according to an embodiment of the present invention before and after discharge is initiated.

Figure 9 is a schematic diagram showing a self-discharge phenomenon in a square wave driving according to an embodiment of the present invention.

Figure 10 is a sketch showing an in-phase split driving for a large backlight according to another embodiment of the present invention.

Figure 11 shows illustrative views of conventional external electrode fluorescent lamps.

Figure 12 is a circuit diagram showing a CCFL driving IC for a conventional LCD panel and a peripheral circuitry thereof.

Detailed Description for Preferred Embodiment

Hereinafter, a fluorescent lamp according to an example of the present invention and a backlight employing the fluorescent lamp will be explained in detail with reference to the accompanying drawings.

Figure 1 shows the fluorescent lamp 10 according to an example of the invention.

Referring to the drawings, the fluorescent lamp 10 includes a cylindrical glass tube 11. The fluorescent substance 12 is applied onto an inner peripheral wall of the glass tube 11. After the fluorescent substance 12 is applied on the glass tube 11, a discharge gas which comprises inert gas, mercury (Hg), etc. mixed with one another is injected into the glass tube, and then both ends of the glass tube are sealed. The glass tube 11 may have a cross-sectional area such as a cylindrical shape, a flat cylindrical shape, or an integrally bent multi-cylindrical shape.

Referring to Figure 1a, end-cap type external electrodes 13 are respectively formed at opposite ends of straight outer peripheral surfaces of both ends of the sealed

glass tube 11. According to the test results of the present applicant, a sufficient length of the cap at an external electrode portion should be secured in order to achieve high luminance and high efficiency of the electrode. Therefore, the external electrode is formed by lengthening the end-cap electrode or bending both ends of the glass tube. The shape of the electrode thus formed includes various shapes such as a "L"-shape, a "C"-shape, a helical shape, a wave shape, etc. Such a curved external electrode is manufactured in various manners that end portions of the straight glass tube are directly bent or that the bent and separately manufactured glass tube with the electrodes installed therein is bonded to both ends of the straight glass tube coated with fluorescent substance, etc.

The external electrodes 13 are made of electrically conductive material and have such a shape that they completely wrap around the ends of the glass tube 11. Fluorescent substance cannot be applied onto an inner portion of the glass tube which corresponds to the external electrode. The external electrodes 13 may be formed by attaching metal tapes or metal capsules to both ends of the glass tube or by dipping the ends of the glass tube into a metal solution, etc. Further, it is preferable that the external electrodes 13 be made of electrically conductive material having a low electric resistance such as Al, Ag, Cu, etc.

In the present invention, if the glass tube is long, end caps disposed at both ends of the glass tube are needed and a belt type electrode at an intermediate portion of the glass tube is not required. The reason is that the longer the distance between opposite ends of the electrode, the more effective the luminance and efficiency of the EEFL. The belt type electrode is unfavorable in view of the luminance and efficiency as compared to the end-cap type electrode. Further, it is unfavorable for making the electrode thinner since its luminance is not uniform due to an electrode portion disposed at the intermediate position of the glass tube.

On the other hand, in order to increase life of the glass tube and to improve the generation of secondary electrons, ferrodielectrics may be applied onto an inner side, corresponding to the external electrode 13, of the glass tube 11, or a separate structure coated with a dielectric may be inserted into both ends of the inner side of the glass tube, which in turn is sealed. Furthermore, in addition to ferrodielectrics, magnesium oxide or calcium oxide, etc., which can serve as a protective film and make the electron discharge easy, may be applied onto the inner side.

Figure 2 shows edge active lighting type backlights according to a second embodiment of the present invention. As shown in the figure, the EEFLs may be disposed around the plastic light guide in various manners. The edge active lighting type electrode can be employed in the external electrode fluorescent lamp of the

present invention, in addition to the cold cathode fluorescent lamp, since the lamp having high luminance and high efficiency can be realized by using the electrode structures such as an end-cap electrode and a curved electrode as shown in Figure 1, and the driving method employed in the present invention. Basically, the lamps of the present invention are plurally disposed at the edge portions of the plastic light guide, and the lamps interconnected in parallel are driven by a single inverter. The lamps of the present invention may be installed on both ends or along all the edge portions of the plastic light guide, and may be multiply installed at each end.

Figure 3 shows direct light type arrangement manners of the EEFLs according to the second embodiment of the present invention. The present invention is characterized in that high luminance and high efficiency are achieved by driving the parallel-connected EEFL by means of the switching inverter. The fine tube having an outer diameter of 2.6 mm can obtain high efficiency at the point of the luminance of about 10,000 cd/m^2. Therefore, in case of a surface light source for high luminance, in which a panel formed by direct light type arrangement has luminance of 10,000 cd/m^2 or higher, the EEFL is disposed on a planar reflecting plate to have smaller spacing between the lamps. However, in case of a surface light source used for several 1,000 cd/m^2, the spacing between the lamps should be adequate and a specific structure of the reflecting plate for improving reflectivity thereof should be employed, in order to achieve a high efficient backlight.

Basically, all the lamps disposed on the reflecting plate are interconnected in parallel and are driven by a single inverter. The area of the electrode portions from which the light is not emitted is minimized by disposing the straight EEFLs at an appropriate spacing as shown in Figure 3a, or by erecting the "L"-shape electrode from the plane as shown in Figure 3b, or by laying the "L"-shape electrode on the plane. In Figure 3d, in order to enhance active lighting efficiency of the lamps, the elongate lamps are disposed in a manner that they are bent at the edge portions of the panel. The type in which the electrodeless lamps are inserted into socket-type multiple capsule electrode structures as shown in Figure 3e is also employed in the present invention.

Figure 3f shows an arrangement manner of the EEFLs for manufacturing an extra-large backlight. In this case, a plurality of the EEFLs are disposed in a longitudinal direction of the lamp, and reflective material is applied on an electrode face or the electrode itself is made of transparent electrode material in order to avoid sudden decrease of the luminance at the electrode portions. In order to compensate for the decrease of luminance at the overlapped portions of the electrodes of the lamps, the electrode portions are alternately disposed and transversely overlapped with each

other at an intermediate portion of the panel. In this case, decrease of luminance is minimized by coating an additional reflective material onto the electrode surface located at the intermediate portion of the panel or by forming the intermediate electrode with a transparent electrode material.

Figure 4 shows a backlight in which the direct light type EEFL according to a second embodiment of the present invention is employed.

Referring to Figure 4, the reflecting plate 21 is provided in the backlight 20. The fluorescent lamps 22 are installed on an upper surface of the reflecting plate 21. As described above, the fluorescent lamps 22 are external electrode fluorescent lamps (EEFLs) in which the fluorescent substance is applied onto the inner peripheral surfaces of the lamps and the external electrodes 23 made of electrically conductive material are respectively formed at both ends of the outer peripheral surfaces of the lamps. In order to maintain their uniform luminance, a plurality of the fluorescent lamps 22 are disposed in a constant interval on the upper surface of the reflecting plate 21 and in a state where they are closely in contact with one another.

Further, in order to electrically connect the fluorescent lamps 22, the current can flow among the external electrodes 23 of the fluorescent lamps 22, and an electrode connecting line 24 is connected to and extends from each of the outermost external electrodes 23a. This causes all of the fluorescent lamps 22 to be driven in parallel when an alternating current type power source is applied thereto.

A diffusing plate 25 is installed above the fluorescent lamps 22 to be opposite to the reflecting plate 21. It is preferred to maintain the diffusing plate 25 suitably spaced from the fluorescent lamps 22 to prevent the image of the fluorescent lamps 22 from being formed thereon, which allows the uniformity of luminance to be improved.

Here, the spacing between the diffusing plate 25 and the fluorescent lamps 22 corresponds to the diameter of the fluorescent lamps 22. For example, if the diameter of the fluorescent lamps 22 is 2.6 mm, the spacing between the diffusing plate 25 and the fluorescent lamps 22 is also 2.6 mm. As a result, the minimum thickness will be 5.2 mm.

The experiment of the applicant shows that the backlight 30 with the EEFL having an outer diameter of 2.6 mm employed therein had a luminance of 10,000 cd/m^2 or more and an efficiency of 50 lm/W or more, and that high heat was not created from the backlight. In particular, the longer the lamp-directional length of the panel using the elongate EEFL, the higher the obtained luminance and efficiency.

Figure 5 shows backlights according to the second embodiment of the present invention, with respect to shapes of the EEFL and the reflecting plate. In Figure 5a, the EEFLs are disposed on a simple planar reflecting plate in the spacing between

adjacent lamps corresponding to the diameter of the lamp. In this case, the backlight is intended to have a luminance greater than that of a single lamp of Figure 4. However, in Figures 5b to 5d, the backlight is intended to have a luminance of the panel less than that of a single lamp and the lamps are disposed in the spacing between adjacent lamps corresponding to several times as large as the diameter of the lamp. In these cases, triangular stands are installed onto the reflecting plate in order to enhance reflectivity thereof as shown in Figure 5b, or a concave mirror type reflecting plate is installed as shown in Figure 5c. Further, the method for enhancing the reflectivity and luminance uniformity of the backlight by inserting the lamps into grooves formed in the plastic light guide and by installing the reflecting plate and the diffusing plate as shown in Figure 5d, can be employed. According to the experiment of the present applicant, the backlight having high efficiency of 50 lm/W or more at the luminance value of 1,000 cd/m^2 or more was realized in a manner that the EEFLs having an outer diameter of 2.6 mm are disposed onto the reflecting plate at the interval of about 15 mm and that the distance between the lamp and the diffusing plate is set to 25 mm.

Figure 6a shows a third embodiment of the backlight 30 according to the present invention before the backlight is assembled, and Figure 6b shows the assembled state of the backlight 30 shown in Figure 6a.

Referring to Figures 6a and 6b, the backlight 30 includes an upper substrate 31 and a lower substrate 32 installed to be opposite to the upper substrate 31. A bottom surface of the upper substrate 31 is formed with an upper layer 33 of fluorescent substance. A top surface of the lower substrate 32 is also formed with a lower layer 34 of fluorescent substance.

A plurality of fluorescent lamps 35 are installed at a predetermined interval above the lower substrate 32. The fluorescent lamps 35 serve to support the upper and lower substrates 31 and 32 when coupled, and simultaneously serve as a partition. External electrodes 36 made of electrically conductive material are installed at both ends of the outer peripheral surface of each of the fluorescent lamps 35, according to the characteristic of the present invention.

In order to supply the backlight 30 with electrical power, an upper electrode 37 and a lower electrode 38 are installed along the outer surfaces of the corresponding sides of the assembled upper and lower substrates 31 and 32, respectively. Each of the upper and lower electrodes 37 and 38 is made of an electrically conductive material and wraps a portion of the outer surface of each of the upper and lower substrates 31 and 32, in the form of a cover. At this time, since the enlargement of the formed area of the lower electrode 38 is advantageous to the obtainment of a

stable electric discharge, it is preferred to dispose the lower electrode 38 on the bottom surface of the lower substrate 32 as large as possible.

Edge supporting stands 39 are installed between the upper and lower substrates 31 and 32 for hermetically sealing them and maintaining airtightness along the edges of the upper and lower substrates 31 and 32. A discharging gas is injected into the backlight 30 before sealed, with the edge supporting stands 39 interposed between the upper and lower substrates 31 and 32.

The upper and lower electrodes 37 and 38 may be separately formed on the substrates 31 and 32, respectively, and then made so that the current can flow on both sides of the substrates 31 and 32. Alternatively, the upper and lower electrodes 37 and 38 may be provided in the form of an integral cover after the substrates 31 and 32 are assembled.

The upper and lower electrodes 37 and 38 are supplied with electrical power via electrode connecting lines 300 connected thereto at both sides of the substrates 31 and 32.

On the other hand, the external electrodes 36 formed on the fluorescent lamps 35 are not connected directly to the upper and lower electrodes 37 and 38 but disposed in a floating state, so that they produce an electric discharge in a manner induced by electrical power supplied to the electrodes 37 and 38. Although the external electrode 36 may be excluded according to circumstances, the installation of the external electrode is advantageous to the obtainment of a stable electric discharge.

When the backlight 30 constructed as such is supplied with electric power through the electrode connecting lines 300, the external electrode fluorescent lamps 35 are separately manufactured and then disposed between the upper and lower substrates 31 and 32 so that they serve as the partition and simultaneously emit light by themselves.

Figures 6a and 6b of the present invention show a fundamental form of a luminant partition type flat panel lamp. Such a lamp has an advantage in that the voltage can be applied to planar external electrode, but has a disadvantage in that high driving voltage should be applied because of an electric capacitive voltage drop due to the thickness of upper and lower glass substrates. In order to improve the foregoing, an electrode, that is made of metal coated with dielectric substance, can be installed on the inside of the planar plate. That is, the lamps can be connected to the electrical power via the electrode connecting lines led to the outside by coupling and sealing the upper substrate and the lower substrate, after multi-capsule electrode structures for mounting the electrodeless fluorescent lamp are installed on the inner portion at both ends of the lower substrate, as shown in Figure 6c. Direct current cannot flow

directly into the electrode, since ferrodielectrics are applied onto an entire surface of the multi-capsule electrode structure. As shown in Figure 6c, upper and lower parts (upper and lower electrodes) are separately manufactured so as to easily apply the ferrodielectrics on the inside of the grooves, and the ferrodielectrics are applied onto the entire surface of the grooves. And then, the electrodeless fluorescent lamps are mounted into the grooves and the upper and lower electrodes are combined.

Therefore, a conventional backlight cannot maintain uniform luminance because a portion where the fluorescent lamps are installed is darkened due to the installation of the fluorescent lamps if the fluorescent lamps are used as a partition. Whereas, according to the characteristics of the present invention uniform luminance can be obtained, because the fluorescent lamps 35 can emit light by themselves. In addition, since the fluorescent lamps 35 also serve as a partition, the glass thickness of the upper and lower substrates 31 and 32 are reduced, which is advantageous to light weight and the enlargement of area.

An inverter, according to another embodiment of the present invention, for driving the backlight having the edge light type and direct light type EEFLs according to the above embodiments, and a method and operation of the inverter will be explained in detail.

The switching inverter, according to an example of the present invention, is a combination of a switching circuit and a boosting transformer. The power source outputs square waves suitable for driving a plurality of external electrode fluorescent lamps interconnected in parallel; it can easily adjust the condition of a frequency and an outputted waveform, and has overshooting portions in the outputted waveform.

The split drive type according to another example of the present invention is applied to a large backlight due to the planar arrangement of the EEFLs, or to a large flat panel lamp in which the electrodes are coated with dielectric layers and an alternating-current type discharge is employed. With the split drive type, the large area is divided into some regions which, in turn, are driven by waveforms having identical phases, thereby reducing the size of the driving apparatus and allowing stable and high speed drive.

Figure 7 shows signal waveforms to be applied to a switching inverter according to an example of the present invention and gates thereof. This apparatus is designed for effectively driving a plurality of EEFLs interconnected in parallel. The circuit of the apparatus is characterized in that contrary to an LC-resonance type inverter used for driving the existing CCFL, it outputs high-voltage square waves by the combination of a boosting transformer and four high-speed FETs serving as switches. Furthermore, a frequency of the outputted square waves, a voltage

maintaining ratio and the like are easily controlled by adjusting each of FET gate signals as shown in Figure 7. The operating principle of the switching inverter according to the present invention is as follows. In the state where DC is applied to the FET installed at the top end of the circuit and to the drains of the gates A and C, the gate signals having the shapes shown in Figure 7 are applied to the respective FETs. Then, in the respective FETs, the gates A and D are simultaneously turned on and then turned off, with the gates C and B also operating in the same manner. At this time, since the boosting transformer is connected to output terminals of the left and right FETs, the electric current flows alternately into a primary coil of the boosting transformer while the respective FETs are turned on. Therefore, the high-voltage square waves shown in Figure 8 are outputted from a secondary coil of the boosting transformer. This outputted waveforms are characterized in that contrary to a sine wave, voltage rising time is short and it has constant voltage maintaining regions. In addition, due to the characteristics of the coil, a transient overshooting voltage is produced in the region where the voltage suddenly varies.

The operation of the inverter will be described in detail below. The outputted voltage waveform in the form of square wave produced from the switching inverter can stably operate the plurality of EEFLs interconnected in parallel to obtain uniform luminance only with one switching inverter, contrary to the existing LC-resonance type inverter. This is because the square wave has a constant voltage maintaining region unlike a sine wave. In the case where the respective EEFLs are turned on by simultaneously applying the square waves thereto, since the applied voltage maintains a constant discharge voltage, unlike a sine wave, even if the respective EEFLs are sequentially turned on within one period of the applied voltage, the lighting of respective lamps becomes uniform to maintain constant luminescence uniformity. This is also because the voltage rising time of the square wave is shorter than that of a sine wave having the same frequency as the square wave. Many space charges and excited molecules remain in the tubes of the lamps after the lamps are sequentially turned on and off by the initially applied voltage, and the space charges among them are gradually recombined with wall charges by an electric field formed between the space and wall charges formed around the electrodes in the initial discharge. The movement of such space charges and excited molecules depend on the intensity and on the change with time of the electric field acting on the tube. Since the voltage rising gradient of the sine wave is always smaller than that of the square wave having the same frequency as the sine wave, the voltage is applied for a relatively long time before starting a second discharge. During that period of time, a kind of wall charge eliminating phenomenon, in which the space charges are

recombined with the wall charges formed in the initial discharge by the electric field formed by the applied voltage, occurs. Due to the above, the amount of wall charges is lowered, which results in reduction of the voltage region capable of maintaining the stable discharge, i.e., the maintaining voltage margin. Thus, the intensity of discharge is also lowered, so that the luminance and the efficiency are lowered. However, the square wave outputted from the switching inverter according to the present invention has a voltage rising time relatively shorter than that of the sine wave and allows the applied voltage to exceed a discharge starting voltage and to start discharging before the space charges are recombined with the wall charges. Therefore, since the wall charge eliminating phenomenon mentioned above becomes insignificant, the maintaining voltage margin becomes relatively larger than that of the sine wave to allow of a stable operation. Moreover, the effect of the steep, rising gradient of voltage allows an instantaneous and fast movement of the space charges, so that the effective collision of the space charges with the neutral and excited molecules increases, thereby imparting additional effects that secondary electrons are actively produced to make the discharge strong and the maintaining voltage margin large.

The overshooting voltage produced in the rising or lowering portion of the outputted waveform of the switching inverter shown in Figure 9 facilitates the starting of discharge, and permits separate adjustment of the output voltage after the starting of discharge to be eliminated. The magnitude of the overshooting voltage depends on the output transformer and the electrical capacity of the EEFL. The inventor found from an experiment that the magnitude of the overshooting voltage has a value of about 20% to 30% before the starting of discharge and is reduced to a value less than 3% while the discharge is maintained after the starting thereof. That is, the effect of the overshooting voltage occurs only before the starting of discharge. The EEFL has the above characteristic since the EEFL has a net capacitive load before the starting of discharge, and has both capacitive and resistive loads after the starting of discharge to produce oscillating attenuation effects by the resistive component of load. As a result, this means that the overshooting voltage has an effect only before the starting of discharge, which facilitates the starting of discharge. Generally, whether a discharge tube is an AC type or a DC type, the voltage before the starting of discharge is higher than the discharge maintaining voltage. If there is an overshooting voltage in an outputted waveform, an applied voltage for starting to discharge may be reduced by that portion. For example, if the discharge starting voltage of a certain discharge tube is 1.3kV and the overshooting portion of a voltage waveform to be applied thereto is 30%, the discharge can start only with a mean output voltage of 1kV. In

particular, the longer the length of the tube of EEFL, the higher the discharge starting voltage. A waveform having an overshooting portion is advantageous when an elongated tube is used. Another important effect is to be able to eliminate a voltage adjusting process generally performed after the starting of discharge. In practice, when a waveform having no overshooting portion is used, a method is employed for artificially lowering voltage on the grounds of the lifetime of the discharge tube, the luminance adjustment and the like after the starting of discharge by application of a voltage required to start on the discharge. Since the switching inverter has a difference of about 20% to 30% in values of peak voltage between before and after the starting of discharge due to the presence of the overshooting voltage, the voltage is automatically adjusted to the level of the maintaining voltage after the starting of discharge, so that it is not necessary to attach a separate voltage adjusting device.

Furthermore, a self-discharge effect by which the efficiency and the luminance are increased appears. The self-discharge is a phenomenon found only in an AC discharge tube, in which when a voltage applied from the outside is lowered and reaches zero potential, in a case where the intensity of the wall voltage induced by the wall charges formed by the discharge is larger than the discharge starting voltage, a discharge occurs among the wall charges. Figure 8 shows the square waves generated from the switching inverter and the self-discharge phenomenon produced when the square waves are applied to the EEFL. In case where the self-discharge is produced, the discharge current and the number of luminescence per period of the voltage waveform are twice as many as those when it is not produced, but the intensity thereof is relatively smaller than that when the self-discharge is not produced. This is because some of the wall charges are eliminated due to production of the self-discharge. If such self-discharge is produced, the efficiency and the luminance are enhanced.

A further embodiment of the present invention is a split drive type of large backlight. A small backlight constructed by disposing EEFLs on a plane can be driven by a single switching inverter. However, since electric power to be consumed becomes large as the area becomes large, the size of a boosting transformer used for the inverter is large. Thus, it is difficult to manufacture a small switching inverter. In addition, if the length of a line for applying a voltage is increased, problems such as signal interference, impedance matching, etc. are caused, thereby causing the luminance not to be uniform. The problems in the above case are solved by employing a split drive manner in which the entire backlight is divided into regions having appropriate sizes and the divided regions are driven by switching inverters for outputting consistently voltage waveforms having the same phase, as shown in Figure

10. Here, the reason why the outputted waveform of each switching inverter must have the same phase is that a leakage of electricity can occur at adjacent portions between the divided regions if the phases are different from each other. The method by which the outputted waveform of each switching inverter has the same phase is to independently connect a FET for performing high speed switching of the switching inverter at each region with a boosting transformer and to share a gate signal for the FETs. At this time, since a circuit for generating gate signals is shared, the cost is saved in comparison with the case where a plurality of switching inverters are used, and the size of the boosting transformer can be reduced to make compact manufacture possible.

As described above, since in the backlight, including the external electrode fluorescent lamps and the method for driving the backlight according to the present invention, the external electrodes are installed at both ends of the outer peripheral surfaces of the fluorescent lamps which, in turn, are disposed on a plane, the following effects are obtained.

First, since the electrodes of the fluorescent lamps are formed at the outside, it is easy to manufacture the fluorescent lamps. By employing the straight end-cap manner or the manner of bending both ends of the glass tube in order to make the length of both electrodes of the glass tube sufficient, high luminance and high efficiency are realized. With the constitution in which the fluorescent lamps are disposed at the edges of the plastic light guide or repeatedly disposed in a plane, the fluorescent lamps are connected to one power source in parallel and can be driven by the power source so that the thin backlight having high luminance and high efficiency which can be easily manufactured is obtained.

Second, since the fluorescent lamps serve as a partition and simultaneously emit light by themselves, uniform luminance can be maintained. Due to the use of the fluorescent lamps as the partition, the thin upper and lower substrates can be employed. Thus, a surface light source having a large area, which ensures uniform luminance, can be manufactured.

Third, since the backlight constructed by disposing the plurality of external electrode fluorescent lamps is driven by a low frequency of several dozen kHz, the problem of EMI can be avoided.

Fourth, since the switching inverter, according to the present invention, with the high speed FET coupled with the boosting transformer outputs high voltage square waves and produces the overshooting voltage, a high speed drive having uniform luminance can be made; the discharge starting voltage can be naturally lowered; and the self-discharge effect can be obtained. With such effects, high luminance and high

efficiency are obtained.

Fifth, according to the switching inverter of the present invention constructed by sharing a gate signal of the FET element and independently connecting only the boosting transformers in order to divide and drive a display screen in the large backlight, the voltage having the same phase is applied to each of the divided display screens, so that leakage of electricity between adjacent divided regions is prevented to make the discharge stable. And thus uniform luminance is obtained in the large backlight. In addition, since the length of line to which the voltage is applied can be reduced and the problems of signal interference and impedance matching can be avoided, it is advantageous to realize the effect of uniform luminance. Furthermore, since the size of the boosting transformer can be reduced and the gate signal generator is shared, a compact switching inverter is obtained.

Moreover, according to the switching inverter of the present invention, i) a plurality of EEFLs interconnected in parallel can be driven at high speed only by one switching inverter to make luminance uniform, ii) the discharge starting voltage can be reduced due to the presence of an overshooting voltage, and iii) the luminance and the efficiency thereof can be enhanced due to the presence of self-discharge.

Although the present invention has been described with reference to the preferred embodiment as shown in the drawings, it should be understood that the embodiment is merely illustrative and those skilled in the art will make various modifications and its equivalents from the embodiment. Therefore, the true scope of the present invention must be defined by the claims attached hereto.

What is claimed is:

1. A fluorescent lamp comprising:
a glass tube into which a discharge gas is injected and which is then hermetically sealed;
a layer of fluorescent substance applied on an inner peripheral wall of said glass tube; and
external electrodes of electrically conductive material formed on both ends of an outer peripheral surface of said glass tube to wrap said ends.

2. An external electrode fluorescent lamp comprising:
a glass tube into which a discharge gas is injected and of which an inner peripheral wall is coated with a layer of fluorescent substance, both ends of said glass tube being then hermetically sealed; and
end-cap type external electrodes configured to take the shape of bends such as a L-shape, a C-shape, a helical shape or a wave shape and to wrap said both ends of said glass tube.

3. A backlight comprising:
a reflecting plate;
a plurality of fluorescent lamps disposed on an upper surface of said reflecting plate, each of said fluorescent lamps having a layer of fluorescent substance applied on an inner peripheral wall of a glass tube of said fluorescent lamp, and external electrodes of electrically conductive material formed on both ends of an outer peripheral surface of said glass tube to wrap said ends; and
a diffusing plate installed above said fluorescent lamps to be opposite to said reflecting plate.

4. The backlight as claimed in Claim 3, wherein a current flows among said external electrodes of the fluorescent lamps, and electrode connecting lines to which an alternating current type power supply is applied are connected to and extend from said external electrodes of outermost fluorescent lamps.

5. A backlight comprising:
an upper substrate with an upper layer of fluorescent substance applied on a bottom surface of said upper substrate;
a lower substrate installed to be opposite to said upper substrate and with a

lower layer of fluorescent substance applied on a top surface of said lower substrate;

edge supporting stand interposed between said upper and lower substrates for hermetically sealing said upper and lower substrates;

fluorescent lamp installed at a predetermined interval said lower substrate, each of said fluorescent lamps having a layer of fluorescent substance applied on an inner peripheral wall of a glass tube of said fluorescent lamp, and external electrodes of electrically conductive material formed on both ends of an outer peripheral surface of said glass tube to wrap said ends; and

electrodes formed at corresponding outer surfaces on both sides of said assembled upper and lower substrates, respectively, and connected to electrode connecting lines to which an alternating current type power supply is applied.

6. The backlight as claimed in Claim 5, wherein said fluorescent lamps are not connected to said electrodes but disposed within said upper and lower substrates in a floating state.

7. A backlight comprising:

a plastic light guide;

fluorescent lamps disposed at edges of said plastic light guide, each of said fluorescent lamps including a glass tube into which a discharge gas is injected and of which an inner peripheral wall is coated with a layer of fluorescent substance, both ends of said glass tube being then hermetically sealed, and end-cap type external electrodes for wrapping said both ends of said glass tube; and

a switching inverter connected to said external electrodes for applying square wave signals having a frequency of 100kHz or lower to said external electrodes.

8. The backlight as claimed in Claim 7, wherein said external electrode fluorescent lamps include a plurality of external electrode fluorescent lamps interconnected in parallel.

9. A backlight comprising:

a plurality of external electrode fluorescent lamps interconnected in parallel, each of said fluorescent lamps including a glass tube into which a discharge gas is injected and of which an inner peripheral wall is coated with a layer of fluorescent substance, both ends of said glass tube being then hermetically sealed, and end-cap type external electrodes for wrapping said both ends of said glass tube;

electrode connecting lines for connecting said end-cap type external

electrodes of said plurality of external electrode fluorescent lamps in parallel;

a reflecting plate;

a diffusing plate; and

a switching inverter connected to said electrode connecting lines for applying a square wave signal having a frequency of 100kHz or lower to said electrode connecting lines.

10. The backlight as claimed in Claim 9, wherein said reflecting plate further includes a plurality of triangular stands interposed between said external electrode fluorescent lamps.

11. The backlight as claimed in Claim 9, wherein said reflecting plate is in the form of wave for wrapping said external electrode fluorescent lamps.

12. The backlight as claimed in Claim 9, further including a plastic light guide having diffusing grooves in which said external electrode fluorescent lamps are seated, and wherein said reflecting plate is in the form of triangular sawteeth and said external electrode fluorescent lamps are disposed along troughs of said triangular sawteeth.

13. A backlight comprising:

glass tubes into which a discharge gas is injected and of which inner peripheral walls are coated with a layer of fluorescent substance, both ends of said glass tubes being then hermetically sealed;

socket-type multiple capsule electrode structures having a plurality of parallel-connected external electrodes with which said glass tubes are coupled;

a reflecting plate;

a diffusing plate; and

a switching inverter connected to said socket-type multiple capsule electrode structures for applying square wave signals having a frequency of 100kHz or lower to said socket-type multiple capsule electrode structures.

14. A backlight comprising:

external electrode fluorescent lamps with external electrode portions thereof alternately disposed and transversely overlapped with each other in the middle of a panel, each of said fluorescent lamps including a glass tube into which a discharge gas is injected and of which an inner peripheral wall is coated with a layer of fluorescent substance, both ends of said glass tube being then hermetically sealed, and cap type

external electrodes for wrapping said both ends of said glass tube;

a reflecting plate;

a diffusing plate; and

a switching inverter connected to said external electrodes for applying square wave signals having a frequency of 100kHz or lower to said external electrodes.

15. The backlight as claimed in Claim 14, wherein said external electrodes of said external electrode fluorescent lamps are made of conductive transparent electrode materials.

16. A backlight comprising:

an upper substrate with an upper layer of fluorescent substance applied on a bottom surface of said upper substrate;

a lower substrate with a lower layer of fluorescent substance applied on a top surface of said lower substrate, said lower substrate being installed to be opposite to said upper substrate;

edge supporting stands interposed between said upper and lower substrates for hermetically sealing said upper and lower substrates;

external electrode fluorescent lamps installed at a predetermined interval above said lower substrate, each of said fluorescent lamps including a glass tube into which a discharge gas is injected and of which an inner peripheral wall is coated with a layer of fluorescent substance, both ends of said glass tube being then hermetically sealed, and capsule type external electrodes for wrapping said both ends of said glass tube;

electrodes formed at corresponding outer surfaces on both sides of said assembled upper and lower substrates, respectively, and connected to electrode connecting lines to which an alternating current type power source is applied;

a switching inverter connected to said electrodes for applying square wave signals having a frequency of 100kHz or lower to said electrodes; and

a discharge gas injected into an inner space upon sealing said upper and lower substrates.

17. The backlight as claimed in Claim 16, wherein said external electrode fluorescent lamps are not connected to said electrodes but disposed within said upper and lower substrates in a floating state.

18. A backlight comprising:

an upper substrate with an upper layer of fluorescent substance applied on a bottom surface of said upper substrate;

a lower substrate installed to be opposite to said upper substrate and with a lower layer of fluorescent substance applied on a top surface of said lower substrate, said lower substrate being installed to be opposite to said upper substrate;

edge supporting stands interposed between said upper and lower substrates for hermetically sealing said upper and lower substrates;

multiple capsule type electrode structures, said multiple capsule type electrode structures being constructed by coupling upper and lower electrodes having surfaces coated with ferrodielectrics and grooves at a predetermined interval and being then installed respectively on inner portions at both ends of said lower substrate;

glass tubes coupled with, in parallel, said grooves of said multiple capsule type electrode structures installed respectively on inner portions at both ends of said lower substrate, each of said glass tubes having a discharge gas injected therein and an inner peripheral wall coated with a layer of fluorescent substance, both ends of said glass tube being then hermetically sealed;

electrode connecting lines connected to said multiple capsule type electrode structures;

a switching inverter connected to said electrode connecting lines for applying a square wave signal having a frequency of 100kHz or lower to said electrodes; and

a discharge gas injected into an inner space upon sealing said upper and lower substrates.

19. The backlight as claimed in any one of Claims 7 to 18, wherein said switching inverter constitutes a bridge circuit by four FETs A, B, C and D; and wherein a DC is applied to drains of said FETs A and C, sources of said FETs B and C are grounded, sources of FETs A and C are connected to drains of said FETs B and D, respectively, and a boosting transformer is connected between a connection point of said FETs A and B and a connection point of said FETs C and D.

20. The backlight as claimed in any one of Claims 7 to 18, wherein a square wave outputted from said switching inverter includes an overshooting.

21. A drive method for driving a backlight with a plurality of external electrode fluorescent lamps interconnected in parallel, comprising the steps of:

dividing said plurality of external electrode fluorescent lamps into a plurality of predetermined regions;

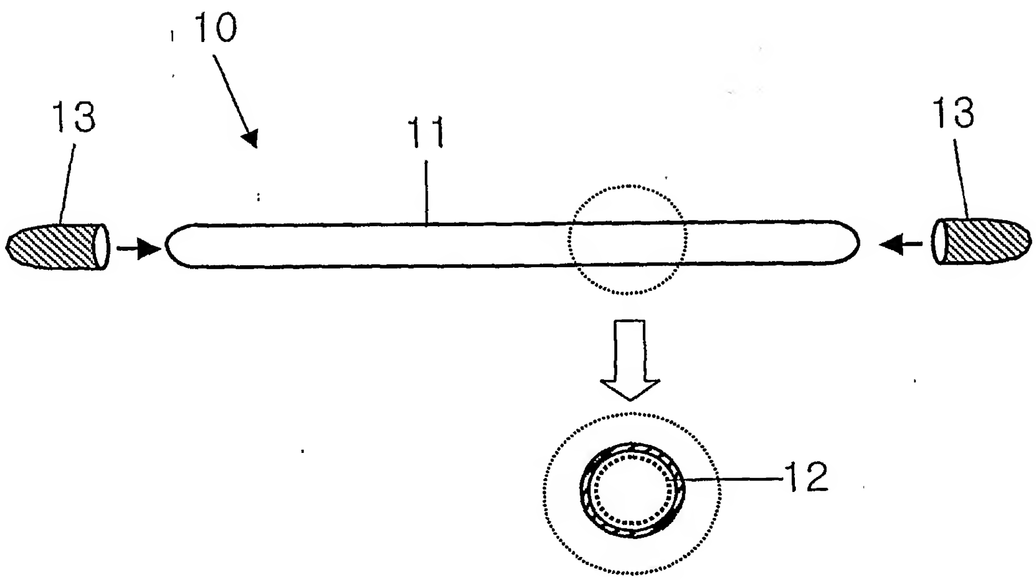
connecting identical electrode connecting lines to external electrodes of said fluorescent lamps in said respective divided regions, respectively;

connecting switching inverters for outputting square waves to said electrode connecting lines connected to said respective divided regions, respectively;

applying an identical gate signal to each of said switching inverters; and

supplying said electrode connecting lines with said in-phase square waves from said switching inverters in response to said gate signal.

22. The drive method for driving a backlight as claimed in Claim 21, wherein said switching inverter constitutes a bridge circuit by four FETs A, B, C and D; and wherein a DC is applied to drains of said FETs A and C, sources of said FETs B and C are grounded, sources of said FETs A and C are connected to drains of said FETs B and D, respectively, and a boosting transformer is connected between a connection point of said FETs A and B and a connection point of said FETs C and D.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12

Fig. 1a

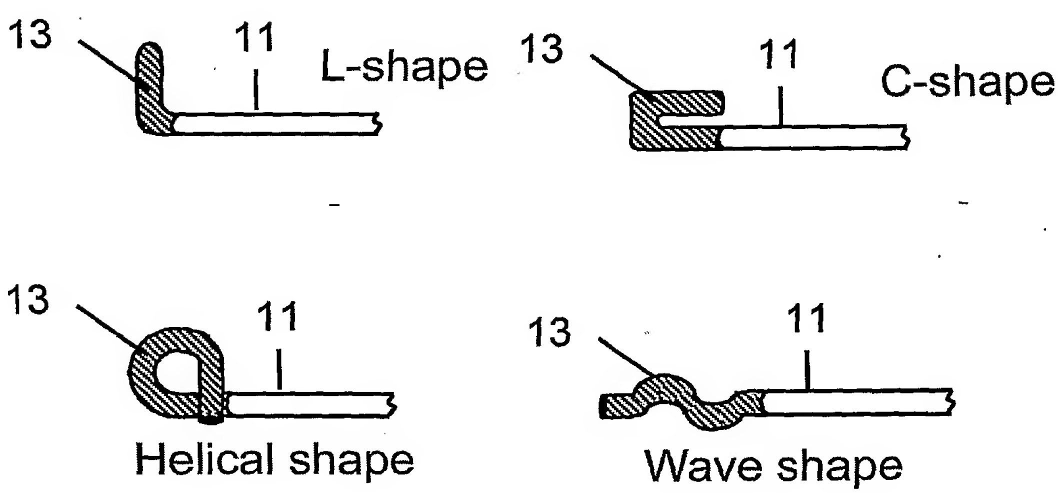

13
11
L-shape
13
11
C-shape
13
11
Helical shape
13
11
Wave shape

Fig. 1b

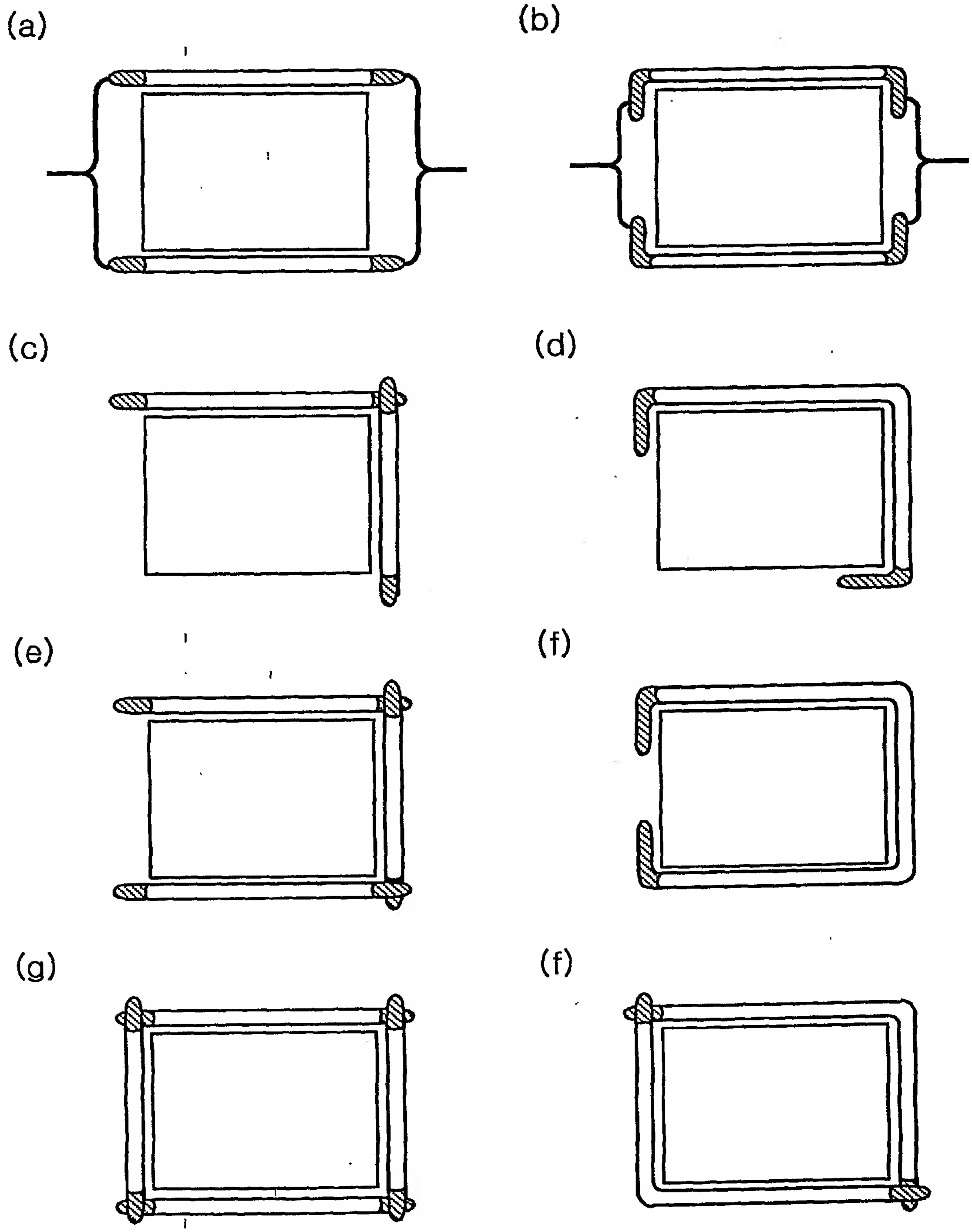


Fig. 2

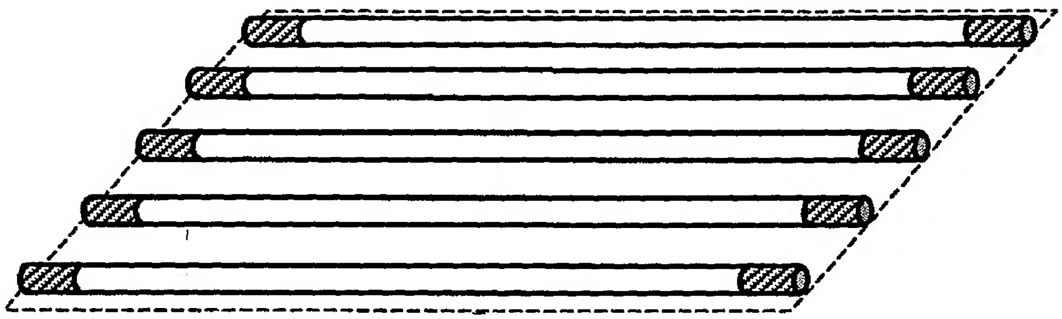


Fig. 3a

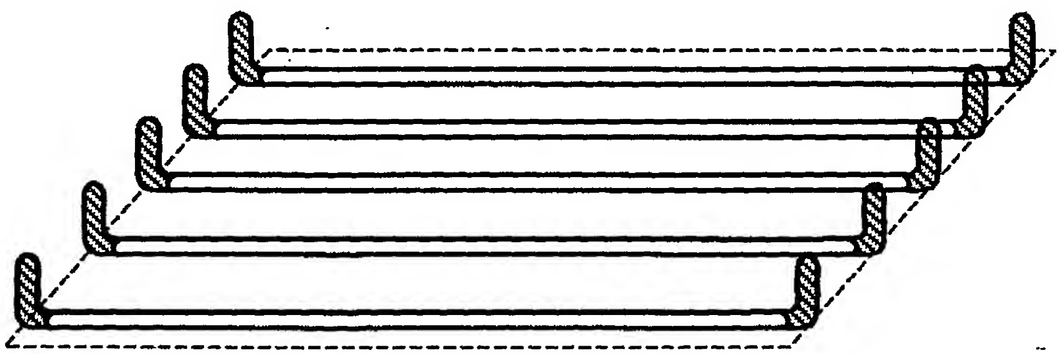


Fig. 3b

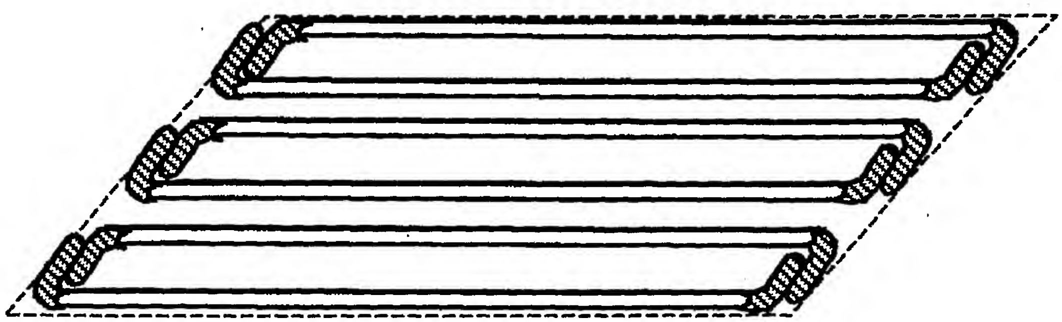


Fig. 3c

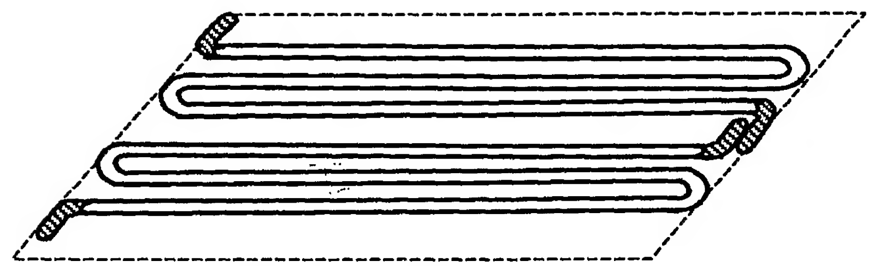


Fig. 3d

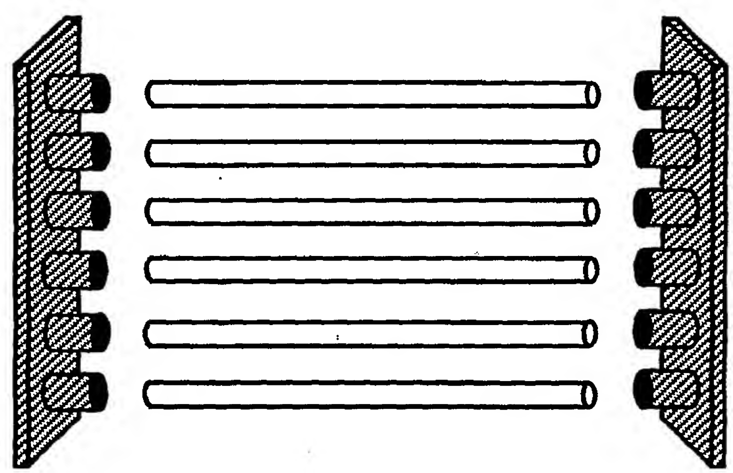


Fig. 3e

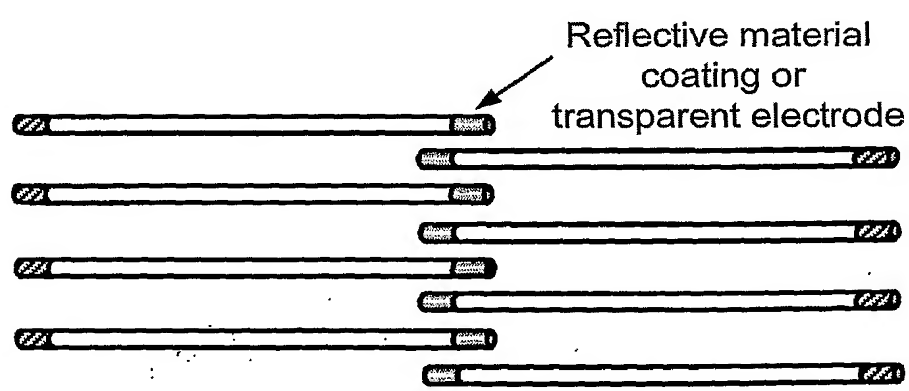


Fig. 3f

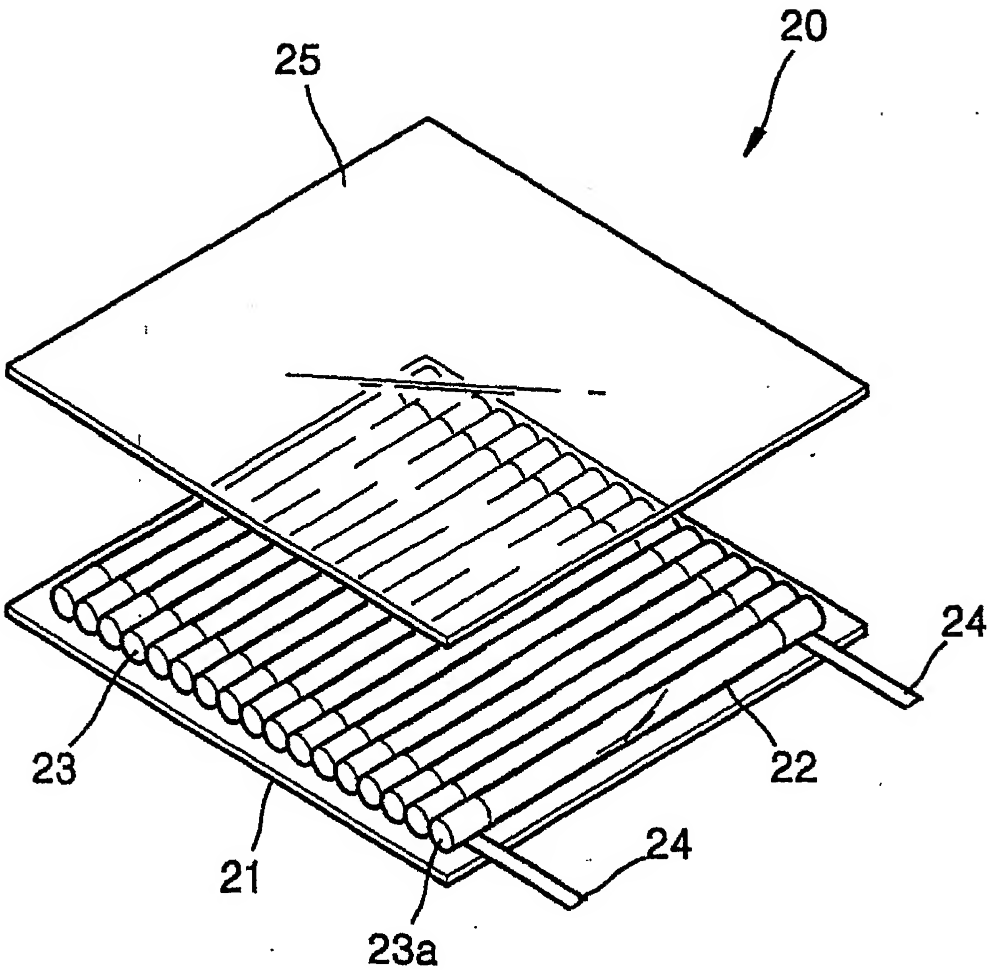


Fig. 4

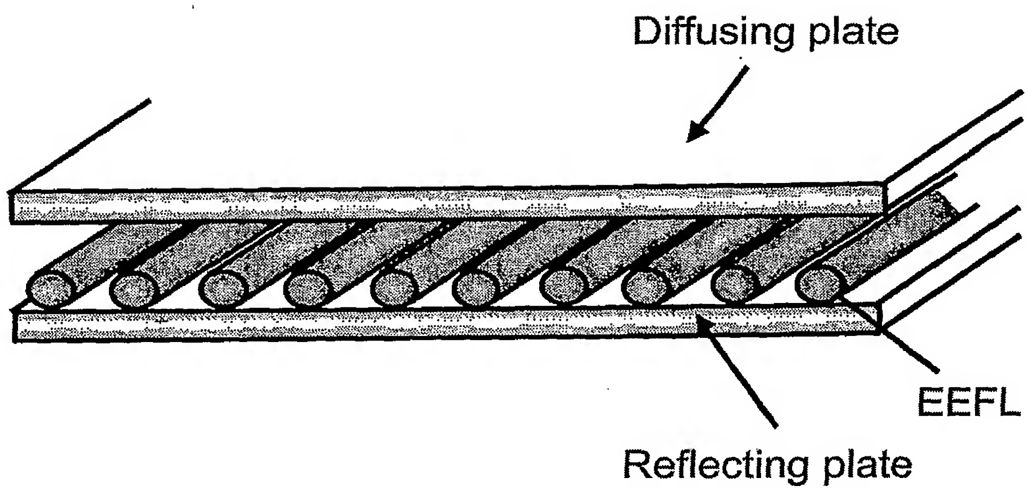

Diffusing plate
EEFL
Reflecting plate

Fig. 5a

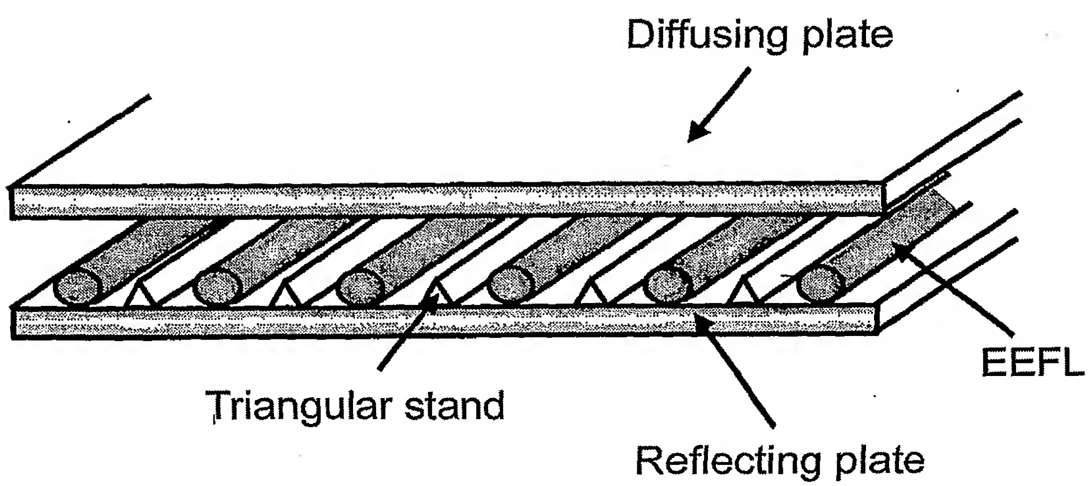

Diffusing plate
EEFL
Triangular stand
Reflecting plate

Fig. 5b

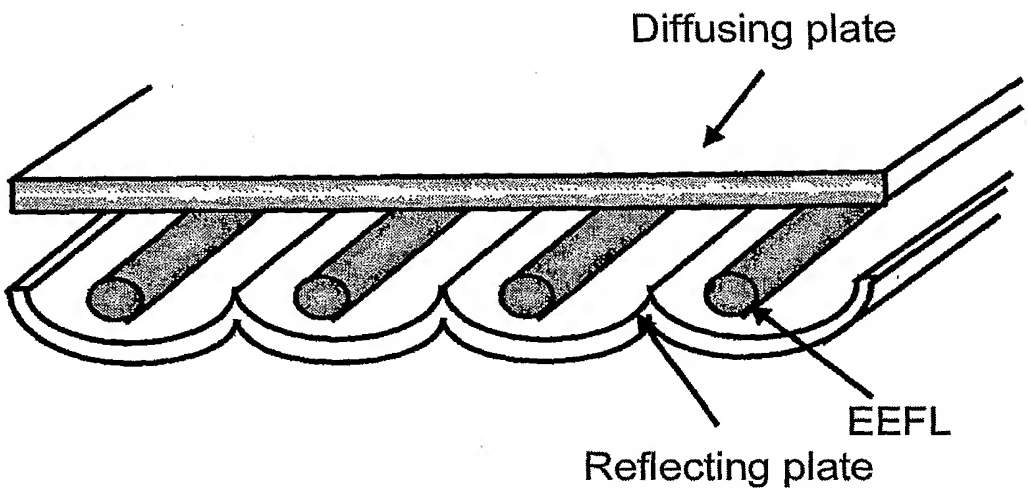

Diffusing plate
EEFL
Reflecting plate

Fig. 5c

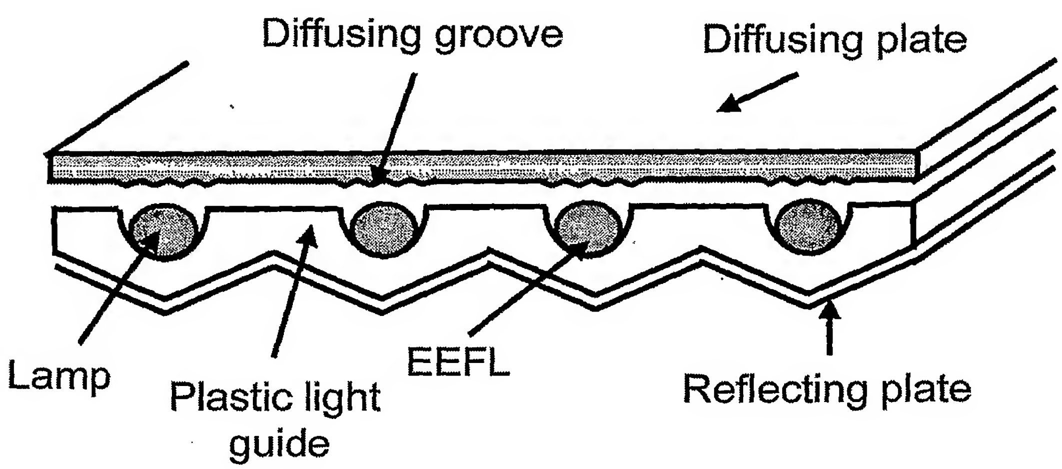

Diffusing groove
Diffusing plate
Lamp
Plastic light guide
EEFL
Reflecting plate

Fig. 5d

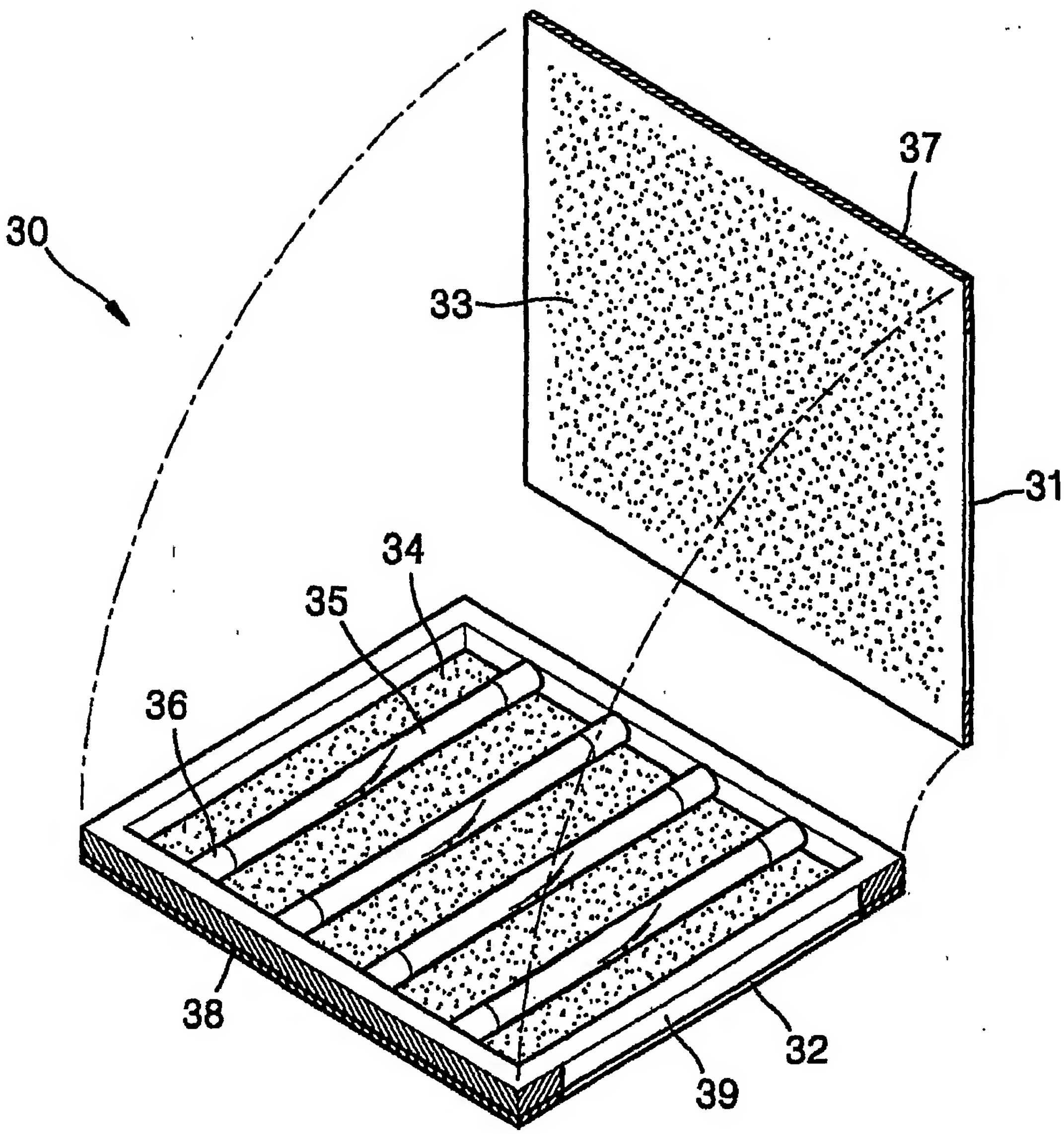


Fig. 6a

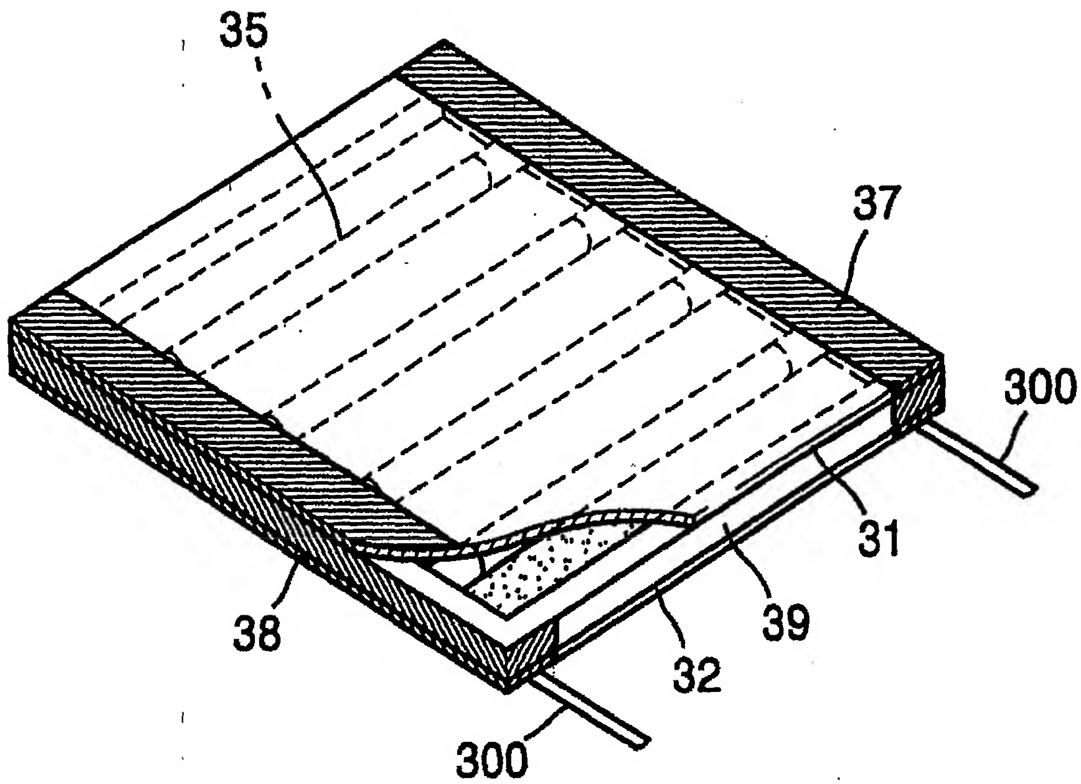


Fig. 6b

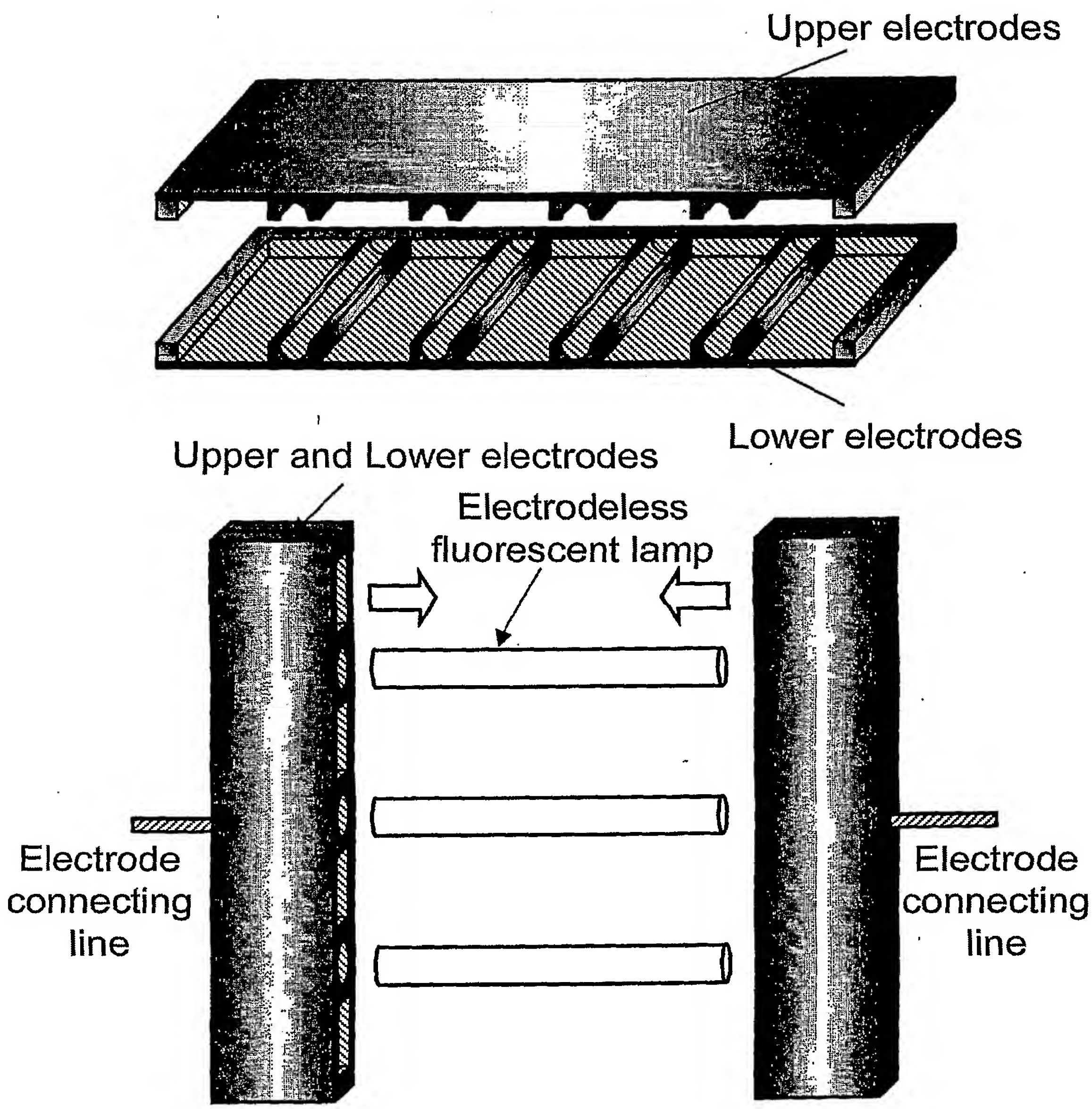

Upper electrodes
Lower electrodes
Upper and Lower electrodes
Electrodeless fluorescent lamp
Electrode connecting line
Electrode connecting line

Fig. 6c

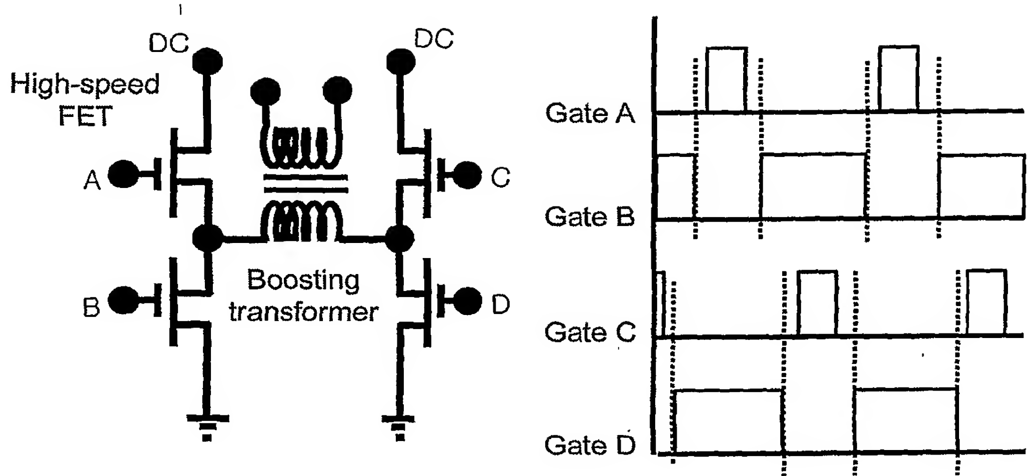

DC
DC
High-speed
FET
A
C
B
D
Boosting
transformer
Gate A
Gate B
Gate C
Gate D

Fig. 7

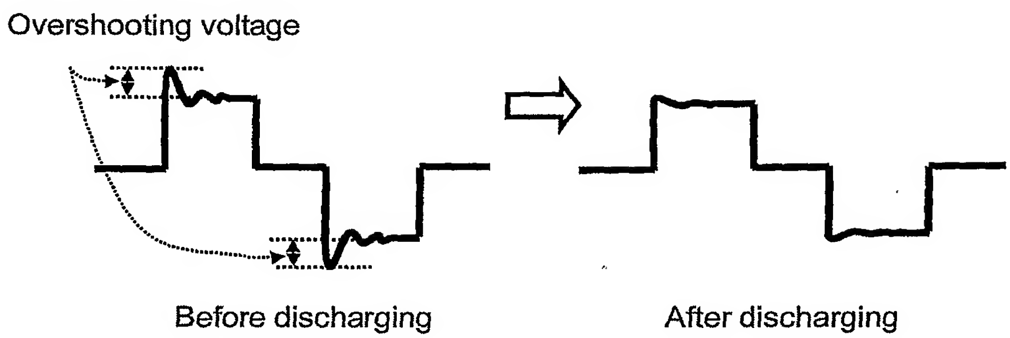

Overshooting voltage
Before discharging
After discharging

Fig. 8

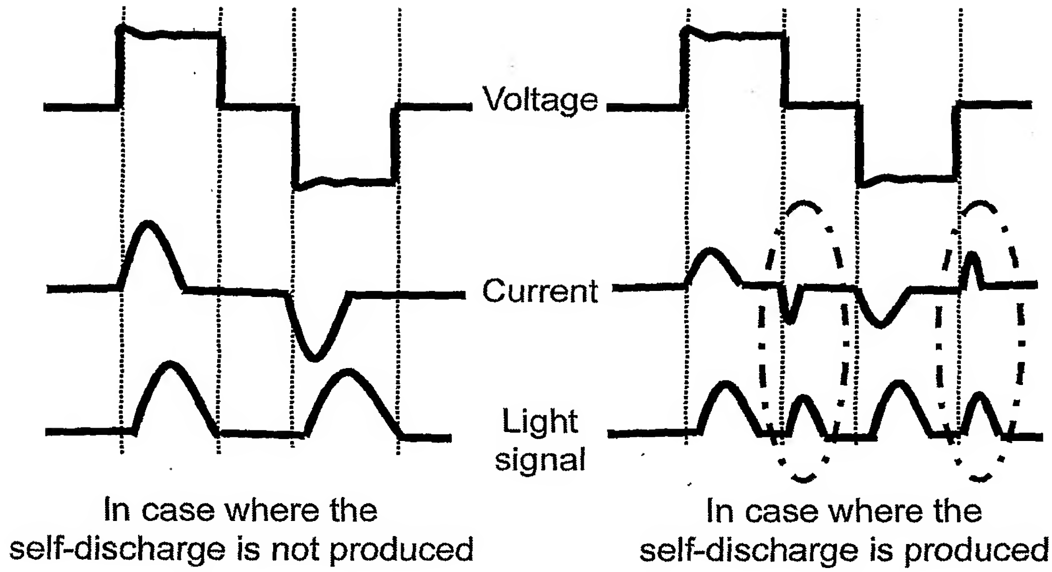

Voltage
Current
Light
signal
In case where the
self-discharge is not produced
In case where the
self-discharge is produced

Fig. 9

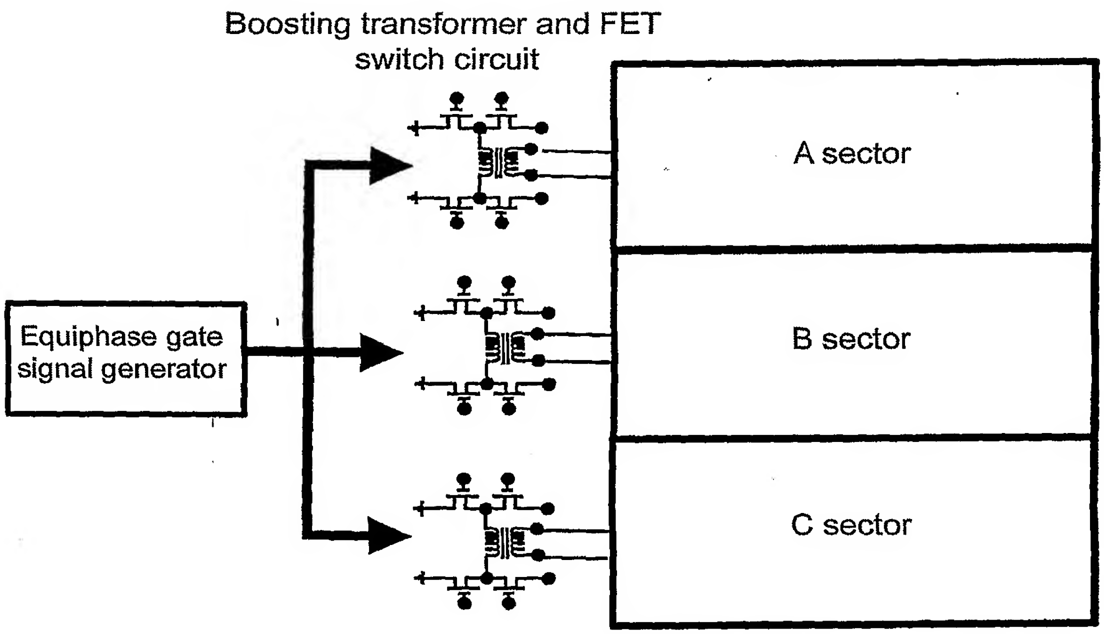
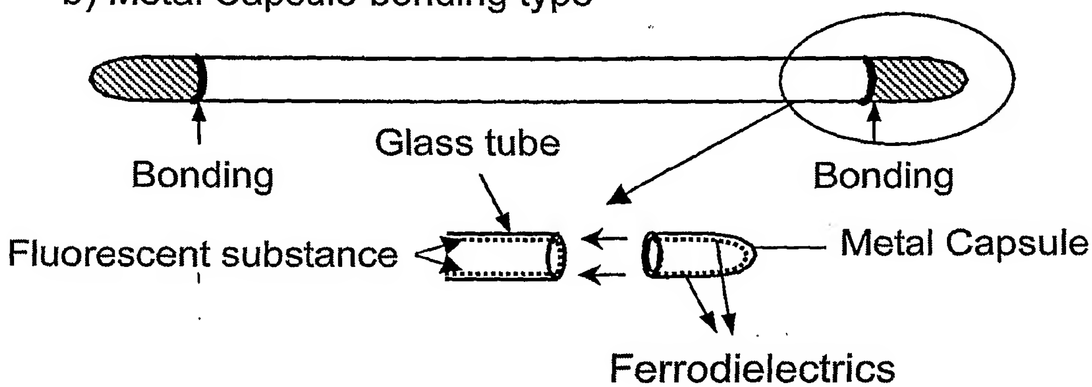

Boosting transformer and FET switch circuit
A sector
B sector
C sector
Equiphase gate signal generator

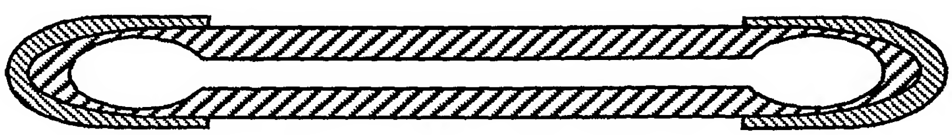
Fig. 10

a) Belt type

b) Metal Capsule-bonding type



c) A type in which spaces at both ends of the glass tube are bulged



d) A type in which spaces at both ends of the glass tube are bulged

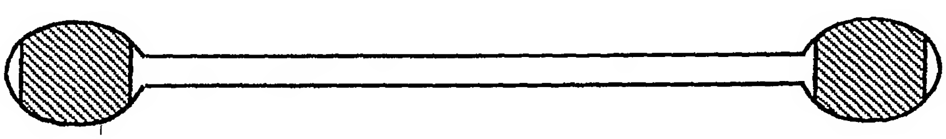


Fig. 11

PRIOR ART

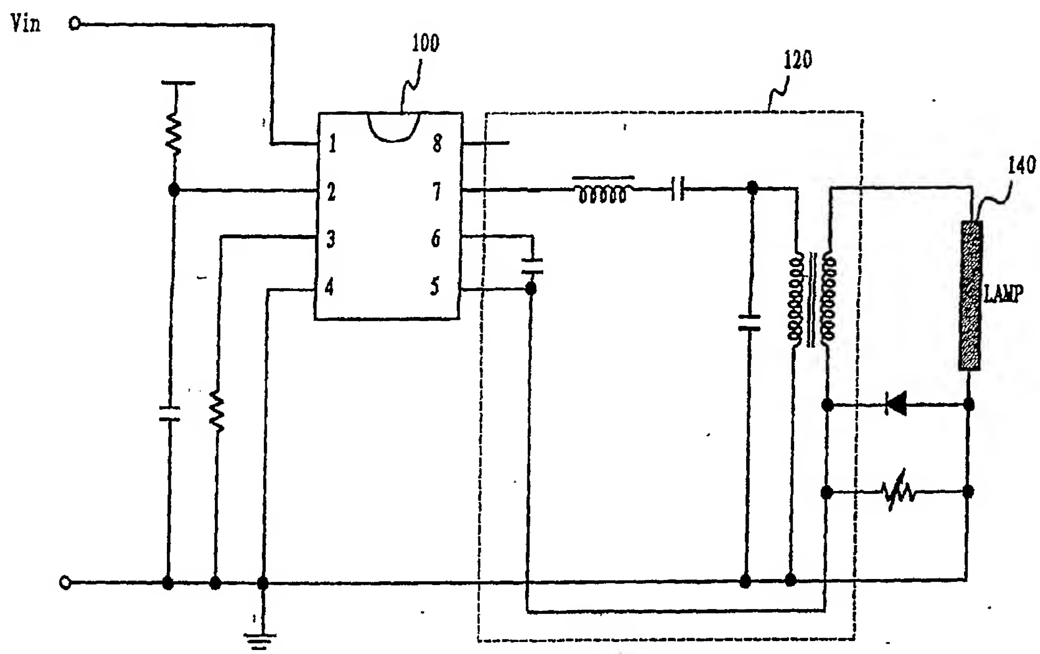


Fig. 12
PRIOR ART

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR01/00423

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 G02F 1/1335

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC7 G02F 1/1335

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean Patents and applications for inventions 1975
Korean Utility model and applications for inventions 1975
Japanese Utility models and applications for inventions 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

JAPIO, INSPECT "BACKLIGHT'

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Jp12-66200 A(SONY CORP) 3 MARCH 2000 see the whole document	1-22

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 JUNE 2001 (28.06.2001)	29 JUNE 2001 (29.06.2001)

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, Dunsan-dong, Seo-gu, Daejeon Metropolitan City 302-701, Republic of Korea	LEE, Su Chan
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5771

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR01/00423

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
Jp12-66200	03.03.2000	None	